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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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Engineering

VOL. CVI.—No. 2759.] *LONDON: FRIDAY, NOVEMBER 15, 1918.* [*Registered at the General Post Office as a Newspaper.*] PRICE 9d. BY INLAND POST ... 10½d.

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See Advertisement, page 34, last week.
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See Illustrated Advertisement November 22nd.

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SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
Repairs on Pacific Coast
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SHIPBUILDERS, SHIP REPAIRERS AND ENGINEERS.

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SPECIALISTS IN
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Yachts, Launches or Barges
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

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See page 107, Nov. 8. 6455

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HEAVY and LIGHT.
All Gauges and Types.
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New Catalogue 12 A mailed on application.

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ELLAND, YORKS. 6812
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See Advertisement page 131, Nov. 8.

Excavators.
FROM 50 TO 600 YARDS PER HOUR.
D. Whitaker, 6263
1, UNION STREET,
LINCOLNSTR.

"Gripoly"
MACHINE BELTING
FOR
Driving
Conveying
Elevating
SOLE MANUFACTURERS
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LONDON. MANCHESTER. GLASGOW.

Iron and Steel
Tubes and Fittings. 6020
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 53, Nov. 8.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, } Row's Patents.
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SYPHONIA STEAM TRAPS, REDUCING VALVES
High-Class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING, 3723

Tubes and Fittings,
IRON AND STEEL.
Stewarts and Lloyds, Ltd.,
41, OSWALD ST., GLASGOW.
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LIVERPOOL WAREHOUSE—62, PARADISE ST.
MANCHESTER WAREHOUSE—34, DEANSGATE.
CARDIFF WAREHOUSE—132, BUTE ST.
BIRMINGHAM WAREHOUSES—NILE STREET, SHERPSCOTE STREET, and 10, COLMEHILL STREET.
See Advertisement page 28. 6462

Die Finished Castings
ensure rapid production and reduce prime cost by eliminating machining operations. Write for illustrations to AERATORS LTD., Edmonton, London, N. 18.

"Petrolex" Fire Extincteur
puts out flaming motor spirit, burning oil, electric arcs and every kind of fire.—BRITISH FIRE APPLIANCES CO., Ltd., 109, Victoria St., London, S.W. 1.

R. Heber Radford, Son & Squire,
ENGINEERING, IRON AND STEEL WORKS
Valuers.
CONSULTING ENGINEERS, SURVEYORS, AND ARBITRATORS.
Established over 50 years. 7106
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Telegrams: "Radford, Sheffield." Telephone: 435.

GOLD MEDAL-INVENTIONS EXHIBITION-AWARDED.
Duckham's Patent Suspended
WEIGHING MACHINES.—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD. LONDON, E.—Hydraulic Cranes, Grain Elevators, &c.
See Illus. Advt. last week, page 18. 7046

STEEL JOISTS,
STEEL CHANNELS,
BRIDGE RAILS, &c.
Fleming Bros.,
STOCKHOLDERS, 7043
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Separators
— FOR —
EXHAUST STEAM TURBINES COMPRESSED AIR &c.
STEAM DRYERS.
METALLIC PACKINGS.
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GUTTA PERCHA & RUBBER, LIMITED,
Toronto - - Canada. 6703

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Destroyers, Torpedo Boats, Yachts and Fast Boats. Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Yarrow Patent
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MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

John Bellamy Limited,
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GENERAL CONSTRUCTIONAL ENGINEERS. 1216
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.
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Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3063

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LIMITED.
See Advertisement page 43, Oct. 25. 3402

Tank Locomotives
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 6450

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GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 6529

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DARLINGTON. 6974

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CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS, OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 120, Trongate, GLASGOW. Od 3547
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Chains (Electrically Welded or hand made) for all purposes; also Chain Fittings, Rings, Hooks, Swivels, Shackles, &c.; Pulley Blocks for use with Chains, Wire Rope or Hemp Rope; Repetition Smithwork and Castings, plain or machined. Reliable quality; prompt deliveries and reasonable prices.—STRINGERS (Cradley Heath), Limited, Cradley Heath, Staffs. 6736

See's Patent Hydro-Pneumatic **Ash Ejector.**
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 30 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4685

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Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
7008
See half-page Advertisement page 55, Nov. 1.

B. & S. Massey, Ltd., MANCHESTER.
Steam Hammers,
Power Hammers,
Drop Stamps,
Band Saws. 6479
QUICK DELIVERY. LARGE STOCK.

The Manchester Steam Users' Association.

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. B. Stromeyer, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 4661

DRAKE & GORHAM, LIMITED.

The 17th Annual Meeting of

Drake & Gorham, Ltd., was held at the Offices of the Company, 66, Victoria Street, London, S.W. 1, on the 13th inst., Mr. B. M. Drake, M.I.E.E., the Chairman of the Company, presiding. In moving the adoption of the Directors' Report and Accounts, the Chairman said:—

"This year's profit of £18,781 compares with £11,330 for the previous year, and constitutes a record, our best year previously being £16,327 in 1903. The profit on turnover works out at under 6% (six per cent), so that we cannot be accused of profiteering.

"I referred last year to the power station already erected for one of the most important Chemical Manufacturing Companies, and to negotiations then in progress for similar work on a larger scale. I am pleased to tell you that we have since been busily engaged on an equipment for an output of 10,000 kilowatts which will be larger than many of the Town Supply Stations in this country. As every modern device is being fitted to produce economical working, I am hopeful that this station will compare favourably with any in the Kingdom. Another generating set of 1000 kilowatts is also being added to the earlier station. Our Manchester Branch has continued its prosperity, and the managers are to be congratulated on the results shown. As we are compelled to give up the Manchester offices which we have occupied for 17 years we have taken others which are now being prepared for us.

"The wholesale merchanting Department, which is conducted as a separate business, has again advanced in turnover. The new Works are an improvement on those previously occupied, and the staff are busy with switchboard work of all kinds and various war appliances. As regards the future I am optimistic, especially if the recommendations of the Electrical Trades Committee (on which I had the pleasure of serving) are accepted by the Government and acted upon without further delay.

"In the published report it is shown that an annual saving of 100 million pounds can be effected in this country if electric power is universally adopted—a sum sufficient to pay the interest on 2000 millions of war stock.

"With electricity 'on tap' throughout the country there must needs be a demand for the services of those who have had the necessary training and experience to show manufacturers how to utilise the current to the best advantage. In this connection we are preparing a scheme of guarantees which will relieve large users from all anxiety as to the saving they will be able to effect."

The resolution was carried unanimously, and the proceedings closed with a hearty vote of thanks to the Chairman. O 557

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. Knowles, B.Sc., Assoc. M. Inst. C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Courses may commence at any time.—30, Victoria St., Westminster, S.W. 7016

A.M.I.C.E. and A.M.I.M.E.

Tuition. Also Postal Courses in Mechanical Engineering, Aircraft Design and Mathematics.—Pennington's, 364, Oxford Road, Manchester.

TENDERS.

TO BE SOLD BY TENDER.—A Prosperous ENGINEERING CONCERN in the West of England.

Messrs. FULLER, HORSHY, SONS, & CASSELL are instructed by the Proprietors, who are retiring from business, to invite

Tenders for the Purchase, in

one lot, as a going concern, of the
BUSINESS and ASSETS
(except book debts) of an old established
ENGINEERING WORKS and FOUNDRY
in an important town in the West of England. The property is freehold, with substantial buildings thereon, equipped with
MODERN PLANT and MACHINERY,
and the Stock, Stores, and Work in progress; as also the
GOODWILL OF THE BUSINESS,
together with the valuable collection of patterns and drawings will be included in the purchase.

Tenders must be in the form contained in the particulars of sale, and should be delivered under seal at the offices of Messrs. Fuller, Horsey, and Co., not later than Four p.m. on
TUESDAY, December 10th, 1918.

Particulars, with plans and conditions of sale, are in course of preparation, and when ready may be obtained (price 5s. per copy) of
FULLER, HORSEY, SONS, & CASSELL,
11, Billiter Square,
London, E.C. 3. O 499

CITY OF NOTTINGHAM.

THE WORKS AND WAYS COMMITTEE are prepared to receive

Tenders for the Supply of the

under-mentioned STORES and MATERIALS, the contracts to commence on the 1st January next, and to terminate on the 31st December, 1919:—
(A) Cement.
(B) Blue Lias Lime.
(C) Red Bricks.
(D) Blue Bricks.
(E) Timber.
(F) Stoneware Pipes, &c.
(G) Stoneware Pipes, &c. (Patent Joints).
(H) Iron Castings, Iron Gullevs, &c.
(I) Yorkshire Flags, Kerb, &c.
(J) Granite Sets, Kerb, and Broken Granite.
(K) Ironstone Slag, Chippings, &c.
(L) River Gravel.
(M) Coal.
(N) Picks, Shovels, Scoops, &c.
(O) Ironmongery.
(P) Scavenging and other Brushes.
(Q) Disinfectants.
(R) Refined Tar.
(S) Pitch.
(T) Creosote Oil.

Forms of Tender may be obtained on applying to Mr. Arthur Brown, M.Inst.C.E., City Engineer, Guildhall, Nottingham, on payment of a deposit of 5s. each, which will be returned on receipt of a bona-fide tender, in accordance with the specifications, providing such tender is not withdrawn, and is delivered by the time stated below.

Patterns and samples may be inspected at the Eastcroft Depôt, London Road, Nottingham.

The committee will not consider any tender except on the authorised form of Tender, which must be delivered to the undersigned, in the official envelope provided, on or before Thursday, 28th November, 1918.

The lowest or any Tender will not necessarily be accepted, and Tenders will only be accepted from persons who conform to the conditions as regards paying the local standard rate of wages, &c., and to the working rules of the Nottingham District applicable to the various trades.

By Order,
W. J. BOARD,
Town Clerk.
Guildhall, Nottingham.
2nd November, 1918. O 390

CORPORATION OF DUBLIN.

ELECTRICITY SUPPLY COMMITTEE.
TENDERS FOR TURBO-ALTERNATOR, ETC.
The Electricity Supply Committee of the Corporation of Dublin desire to receive

Tenders for the supply and

INSTALLATION at their Pigeon House Generating Station of a complete GENERATING SET of approximately 2000 to 5000 K.w. capacity.

This set to form a complete unit, comprising steam-turbo alternator and exciter, condensing plant, the necessary steam and water piping and foundations.

As the entire plant must be completed for beneficial use at the earliest possible date, it is necessary that intending Tenderers should at once inspect the site in order that they may be fully informed of the conditions to be complied with as to space and local requirements, and no Tender will be considered which is not based upon such inspection.

General Conditions, Specification and Form of Tender may be obtained from the City Electrical Engineer, Fleet Street, Dublin, on and after Thursday, November 14th, 1918, on payment of Three Guineas, which sum will be refunded on receipt of a bona-fide Tender.

Tenders sealed and endorsed "Tender for complete 3000-5000 Kw. Steam-turbo Generating Plant," must be addressed to "The Chairman, Electricity Supply Committee, 3, Cork Hill, Dublin," and delivered there not later than 12 o'clock noon on Wednesday, November 27th, 1918.

The Committee do not bind themselves to accept the lowest or any Tender.

FRED. J. ALLAN, Secretary.
Electricity Supply Committee Offices,
3, Cork Hill, Dublin. November 11th, 1918. O 558

CONTRACTS, &c.

GREAT SOUTHERN & WESTERN RAILWAY (IRELAND)

CONTRACTS, 1919.

The Directors of the Great Southern and Western Railway Company are prepared to receive

Tenders for the Supply of

the undermentioned STORES for Twelve Months to 31st December, 1919, or part of that period:—

	No. of Form.		No. of Form.
Acid, Sulphuric ...	3D	Incandescent Fittings for Gas	26C
Baskets	10	India Rubber Goods	9A
Bolts, Nuts and Rivets	15	Implements, Sundry	21
Brooms and Brushes	13	Iron Tubes and Fittings...	29
Brass Fittings for Carriages	18	Iron and Steel Wire	30A
Do. do. for Lamps	18A	Leather	12
Do. do. for Water	26A	Linen	8
Do. do. for Gas ...	26B	Linoleum	7B
Bunting	7B	Locks and Keys ...	19
Canvas and Sacks ...	6	Mats, Fibre	10
Carriage Laces ...	7A	Morocco	7B
Castings, Mall. Iron	11	Nails	31
Cement	34	Oak Keys	35A
Cloth Carr. and Uniforms	7C	Oak Trenails	35B
Clothing, Oil... ...	9B	Plumbago	41
Do. I.R. proofed	9B	Railway Fastenings (Iron)	16
Coach Screws and Washers	15	Railway Fastenings (Steel)	16A
Coloure	2	Rain Water Pipes and Gutters	25
Corks	39	Ropes, Twine, and Plax	4
Cotton Waste ...	5A	Sewer Pipes, Plaster, etc.	32
Crucibles	41	Shovels, Spades, etc.	21A
Curled Hair	7B	Soft Goods	8
Drysalteries	3	Sponge Cloths	5
Emery and Glass Cloth, etc.	38	Signal Wire Pulleys	11
Files and Tool Steel	20	Screws and Split Pins	14
Fire Bricks and Clay	33	Tin Plates	23
Foundry Requisites	42	Varnishes	1
Galv. Sheets, Buckets, etc.	23	Waste	5A
Grates, Stoves and Fenders	24	Waterproof Clothing	9B
Grindstones	28	Wicks	5
Glass, Sheet and Plate	27A	Wire, Fence and Signal	30A
Glass and China Sundries	27B	Wirework	30B
Hardware (Sundry)...	17		

Forms of Tender can be obtained on *PAYMENT* of 5s. each from the COMPANY'S STOREKEEPER, AT THE GENERAL STORES, INCHICORE, Dublin, to whom enquiries for information should be made direct. Patterns may be inspected at the same place on and after the 18th instant between the hours of Ten a.m. and Four p.m. (except on Saturdays).

The Tenders to be sent in endorsed "Tenders for Stores," and addressed to the undersigned, so as to be with him before Ten o'clock, a.m., on Wednesday the 27th November, 1918.

The Directors will not consider any Tender except those furnished on the Company's Forms, and do not bind themselves to accept the lowest or any Tender.

By Order,
(Signed) ROBERT CRAWFORD, Secretary.
Kingsbridge Terminus, Dublin,
November, 1918. O 519

KIDDERMINSTER.

TO BE SOLD BY TENDER, as a Current Going Concern, the BUSINESS and ASSETS (except Book Debts) of Messrs. PRUNELL, LAMB & CO., Road Traction and Agricultural Engineers and Machine Makers.

Messrs. FULLER, HORSEY, SONS & CASSELL are instructed by the Proprietor, who is retiring, to to invite

Tenders for the Purchase, in

one lot, of the
FREEHOLD ENGINEERING WORKS,
situate in the main thoroughfare, known as Station Hill, Kidderminster, with substantial Buildings thereon, equipped with
MODERN FIXED PLANT and MACHINERY.
The whole of the Stock, Stores, Work in Progress, Loose Plant, Tools, Utensils and Patterns, and also the
GOODWILL OF THE OLD-ESTABLISHED BUSINESS,
will be included in the purchase, there being no obligation on the buyer to take anything at a valuation.

Tenders, which must be on the form contained in the Particulars of Sale, should be delivered at the Auctioneers' Offices by Four p.m. on
THURSDAY, December 5th, 1918.

The Works may be viewed by orders only, to be obtained of the Auctioneers, and Particulars with Conditions of Sale had of H. G. IVENS, Esq., Solicitor, High Street, Kidderminster, or of Messrs.
FULLER, HORSEY & CO.,
Mechanical Auctioneers and Valuers,
11, Billiter Square,
London, E.C. 3. O 530

APPOINTMENTS OPEN.

KENT EDUCATION COMMITTEE.

JUNIOR TECHNICAL SCHOOL, MAIDSTONE

Required immediately, chiefly

for day work in the Junior Technical School, an ASSISTANT MASTER or MISTRESS qualified in science and mathematics. Initial salary, woman £200; man, with engineering science qualifications, £250.

Apply immediately to PRINCIPAL, Technical Institute, Maidstone.
R. SALTER DAVIES,
Director of Education.
September, 1918. O 483

GREAT NORTHERN RAILWAY COMPANY, IRELAND.

The Great Northern Railway Company, Ireland, Require the

Services of a Works Manager

for their Locomotive, Carriage and Wagon Department at Dundalk, to act under the Locomotive Engineer.

Applicants must have a knowledge of piecework as applied to the repair of Locomotives and Rolling Stock.

Salary £450 per annum.

Applications, stating age and giving particulars of experience, accompanied by copies of testimonials should be forwarded to the Secretary, under cover marked "Private," not later than the 30th November, 1918.

By Order,
T. MORRISON, Secretary.
Secretary's Office,
Amiens Street Terminus,
DUBLIN, 12th November, 1918. O 496

Chief Electrical Assistant

WANTED for the Engineering Department of large industrial company in the south of England. Must have had good experience in both A.C. and D.C. factory work and generating plants, estimating, costs and repairs. Thoroughly experienced men only with good technical training should apply in writing, giving concise outline of training and experience with copies of testimonials (no originals will be returned), also stating age and salary required.—Address, O 537, Offices of Engineering.

Engineer.—The Services of

an Engineer with 17 years' experience will be AVAILABLE at the termination of the War. Experience as follows: 4 years' apprenticeship, 4 years' Harbour Construction in Great Britain, 3 years' Hydro-Electric Development, 3 years' Municipal in America, 3 years with Government on Aircraft Engine inspection.

Negotiations with a view to appointment (when available) will be willingly entered into now, the intervening time, as far as possible, will be devoted to the collection of any special data, language, &c.

Excellent references can be furnished.
Address, O 475, Offices of Engineering.

Engineer, with First-class

Mechanical and Electrical training WANTED FOR ESTIMATING AND CONTRACTS by large Electrical Manufacturing Co. in Midlands. No person already on Government work will be engaged.—Apply, giving experience, salary required and when can commence, to your nearest EMPLOYMENT EXCHANGE, quoting No. A-6363. O 494

Machining Estimator Re-

QUIRED in the Planning Department of an engineering firm in the neighbourhood of Bristol manufacturing aero engines.—Applications from those not already engaged on Government work should be made to nearest EMPLOYMENT EXCHANGE, mentioning this Paper and No. O 490, stating age, experience and salary required.

Required for an Important

provincial Gas Company, an experienced and fully qualified CONSTRUCTIONAL ENGINEER, with special knowledge of modern Gas Works Design, and Coal Handling Plant. Salary appropriate to qualifications.—Write, giving full particulars to O 286, Offices of Engineering.

The National Boiler & General

Insurance Co., Ltd., St. Mary's Parsonage, Manchester, REQUIRE Additional Electrical INSPECTORS. Must be practical electrical engineers with experience of dynamo construction and repair, also electric wiring. Should have theoretical knowledge and be able to take dimensions and make neat sketches of electrical appliances. Duties include the examination of dynamos, motors, wiring, various parts of electrical installations, and testing of same. Salary £166 per annum, plus war bonus £33. Applications from men eligible for military service are not invited.—Address by letter only, marked "Electrical Inspector," giving age, outline of experience, certificates and copies of testimonials, EDWARD C. HILLER, Chief Engineer. O 515

Manager Required for Small

Steel Foundry in Hong Kong, which is being enlarged and reorganised. Applicants must be able to advise and superintend the laying out of modern steel foundries, including crucible, electric and open hearth furnaces. Applications from suitable discharged men would be considered.—Apply, stating age, experience, qualifications, salary required, references, &c., to BOX 789, care of Leathwait & Simmons, 5, Birchin Lane, E.C. 3. M 718

Wanted, Works Manager,

with special knowledge of Accumulator manufacture, preferably with experience of Traction batteries. Must be practical, energetic and good organisor. Applications must contain full particulars of experience and salary required. Only first-class men need apply.—Address, O 284, Offices of Engineering.

Wanted Purchasing Clerk

should have experience in purchasing Electrical Stores and Fittings, Works Stores, etc. Applications must contain full particulars of experience and salary required.—Address, O 285, Offices of Engineering.

Wanted a Cost Clerk, Pre-

ferably with experience in Cable and Electrical manufacture. Must be capable of instituting and organizing detailed Costing Department. Applications must contain full particulars of experience and salary required.—Address, O 286, Offices of Engineering.

Office Staff Vacancies Occur

For Index, Invoice, Entering, Assistant and Junior CLERKS in an Aeroplane Factory, London District. Preference shown to discharged soldiers and sailors. No one already on Government work or resident more than 10 miles away will be engaged.—Reply stating age, full particulars of experience and salary required to O 480, Offices of Engineering.

Naval Architect Wanted for

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Engineer of Methods, for

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TEMPLETS, JIGS AND FIXTURES.—No. XV.

By Joseph Horner.

The growth of the practice of tooling in series—continuous tooling—is inseparably linked with the employment of fixtures, though much of it is done on articles that are fixed directly to the tables of machine tools. But there is an important difference. In these the gain is not that in time occupied in fixing, but is that of time saved due to the cutting of a number of pieces either on reciprocating, or rotating tables. In the first the number of reversals is reduced proportionately to the length of travel, in the second the gain results from the large number of pieces included in a revolution. The economy afforded by the use of an intermediate fixture includes these, but the principal difference is that between attaching pieces in series directly to a table, and that of securing them in an intermediate holder—the fixture. And the more intricate the shapes of the articles are, the more flimsy their proportions, and the more destitute of suitable broad bases, or of projections by which to set and secure them directly on a table, the greater is the gain derived from the employment of a fixture. Numerous examples in this series have strikingly illustrated the extreme rapidity with which the most awkwardly-shaped pieces—troublesome shapes to deal with from the machinists' point of view—can be located and held in fixtures suitably designed to fulfil just their one special function. And these methods by which single pieces of large and moderate dimensions are dealt with are equally available when small articles are mounted a dozen, or a score in succession.

The practice of continuous tooling marks as great an advance on the single work-holding fixture as this does on the older practice of setting work directly on machine tables. Many fixtures, in fact, for continuous tooling comprise as many distinct and separate work-holding blocks as there are pieces to be tooled, all being attached to a common base. The practice of course has its limitations, being controlled by the dimensions and the numbers of pieces that can be treated at one time in a machine of given capacity. Generally, the larger the articles are the fewer are the numbers that can be mounted in a single fixture. But machines with enlarged capacities and increased adaptabilities are keeping pace with ever-widening demands. Since, too, with increase in numbers the work-holding elements must be correspondingly multiplied, this adds to the cost of continuous fixtures, so that their construction can only generally be justified by an output that runs into many thousands of pieces. And yet some records show such vast gains achieved by the adoption of this system that the cost of the fixture sinks into insignificance. Such records as one continuous miller producing as many pieces in one hour as had previously occupied three days on other machines with work attached to tables. Or that of one continuous milling fixture turning out about 80 more pieces per hour than had been previously accomplished on four other machines. In such comparisons not only are the total relative outputs to be regarded, but also the capital outlay on machines, on cutters, and their upkeep, shop space occupied, and the wages of attendants. Spread these over a year, and compare these totalled costs with that of the fixtures, and the figures speak for themselves wholly in favour of the latter.

There is another aspect of the subject, that of the time saved in fixing up the pieces. To realise how much is involved in this it is desirable to remember the differences observable in so many examples in this series in the time occupied in fixing relatively to that of tooling, differences in time which are sometimes often scarcely comparable when articles are set up directly on the faces of machine tables, and when they are loaded into a fixture that has been designed skilfully and specially for their reception. On a table there must be levelling, adjustments, packing, clamping with different methods of probable greater or lesser utility open to selection, and the necessary employment of appliances, of loose pieces, packings, clamps, bolts, vee-blocks, angle plates and others to suit all shapes and characteristics of a varied class of general work; as thin, flimsy, thick, and massive, cubical, or circular, each of which has to be suitably located and held against the stress of cutting, yet without suffering distortion or risk of fracture. And these precautions and details, often tedious, have to be repeated with every separate piece, however numerous the total. But the fixture, once prepared, involves no tentative settings, no methods of trial and error, no hesitation in the selection of fastenings, no problematical issues. It takes charge of all the locations and clampings, all reduced to their simplest possible elements and movements. Expedition takes the place of hesitation. For the skill of the experienced machinist, the deft fingers of the attendant are substituted, whose chief task is to load and unload articles without stopping the revolving table to do so.

Though the economies of fixing work may be multiplied a dozen or twenty times over in a rotating body carrying as many separate pieces, this does not entail any sacrifice of accuracy. Far from it, since all the pieces are held in precisely similar positions in their common fixture, and the tools work, or are fed to work, to finely-gauged thicknesses or depth dimensions, rendering the tooled parts interchangeable. And, further, the economies of multiple tooling more or less can often be included, as by the employment of gang mills, and of double sets of tools on machines provided with two spindles, or two, four, or more tool heads. The primary gain, however, is that which is achieved by the tooling in series.

The difference between clamping castings singly on a table, and a dozen or more in a fixture affects enormously the ratio of the time occupied in tooling to that of setting and securing. An aim of the present day manager is to find the irreducible minimum of setting, as much as of tooling. The solution is only to be found in the use of fixtures, and in increasing the number of pieces carried in a fixture. The actual cutting time when direct setting on tables is adopted is often less than the setting-time when small articles are concerned. But using a suitable fixture, the time of setting bears only a minute proportion to that of tooling, and the difference becomes more accentuated as the dimensions of the pieces and their complexity of form increases. In very small articles tooled continuously the time of setting and of tooling practically coincide.

Tooling in series must be nearly as old as machine-shop practice. But formerly the pieces were attached directly to the tables of the machines. Some articles lend themselves admirably to this method. Those having broadly rectangular outlines with stout lugs or flanges to receive clamping plates afford facilities for rapid setting-up. Cylindrical articles, or those having circular projections, can be arranged in series in vee-blocks. Those that have flat faces to be tooled at right angles are readily carried in succession on long angle plates. Segmental shapes to be turned, bored and faced, can be quickly set in a circle on the tables of vertical boring and turning mills. All these are old methods, still commonly retained.

Series, or string-fixtures as distinguished from those which are mounted on rotating tables, are adopted when it is desirable to avoid lost strokes. Instead of putting a single short piece on a shaper table or on a short-stroke planer, a dozen perhaps may be set on a long-stroke planer, or plano-miller, and the time occupied in return strokes mostly saved. The economy may be increased when table dimensions permit by attaching double or treble rows of pieces. Even if each piece has to be dealt with individually when fixing up, some time is often saved, as when a single packing, and a single clamp plate and bolt is utilised to secure adjacent pieces.

Before the present growth of the practice of continuous tooling had developed an approach was being made to it chiefly in the form of plain plates or plain open frames to which a number of separate pieces of similar articles were attached, and which was itself bolted to the machine table. These were more or less crude anticipations of later forms of fixtures, many of which are still in regular use on planer tables. The advantage gained in addition to that of saving lost strokes is that almost any such intermediary piece, however rough provides setting blocks, stops, and special clamps suitably made for the work to be carried. It only differs from improved designs in its less highly-developed details. It saves much time otherwise occupied in slow adjustments, settings, and fixings directly on tables with loose clamps, packings, and bolts.

When continuous tooling fixtures are mentioned the term visualises those which rotate on the grinder or the milling machine. Strictly, this view is not correct, though convenient. When string fixtures are mentioned the term applies to those which are carried on the tables of reciprocating machines as Lincoln millers, plano-millers, planing machines, and the rotary surface grinders with reciprocating tables. There is perhaps an equal volume of work done on each class of machine, and it is all substantially and in effect, though not strictly, continuous tooling. The selection of a machine must, of course, in many cases be determined by the shapes, and principally by the dimensions of the pieces to be dealt with. In very many of small dimensions all the advantage lies with the vertical spindle milling machines, using straddle cutters which tool lower faces as readily as upper ones. Tooling on opposite faces can only be done on other machines by adopting a different setting of the articles, which is not always convenient. It is therefore only consonant with reason, easily understood that great advances have latterly been made in the designs of rotary milling fixtures for use on vertical spindle machines. The vertical spindle face grinders are, as we have seen in this series, employed largely, but their range of action is more limited than that of the millers, since they can only deal with one face at a time.

The rotary machines now appropriate an immense volume of automobile details for which mass production is an economical necessity. The enormous resulting outputs, products inseparable from fixture design, wholly impossible without these aids, must sweep the field of rival firms who elect to adhere to ancient ways. The question is no longer one of task-driving, and hard swearing as in the bad old days of intensive hand labour. Successful manufacture now is associated with enhanced machine-tool production, and this is a triumph of intelligence rightly directed. The photographs reproduced in the Plates accompanying this issue reveal vividly the possibilities of this particular class of machine-tool production. And doubtless these are not the final developments possible, and to be rendered practicable, by the aid of continuous fixtures associated with multiple tooling.

The examples referred to are from the shops of the Becker Milling Machine Company,* of Hyde Park, Mass., U.S.A., represented in England by the Selson Engineering Company, Limited, of 35, Queen Victoria-street, E.C. They illustrate in a great variety of details the vast possibilities of the system of which they are exponents. A close study of these photographs suffices to reveal the reasons of the recent rapid growth of the practice of continuous tooling. They show, too, so much of detail that they tell nearly as much as sectional drawings would do.

Drop-forged connecting rods for automobile engines are dealt with in large numbers in fixtures. The first three photographs illustrate diverse methods of locating and holding these. In each case four boss faces are being finished at one time with straddle mills. This is multiple tooling which could not be accomplished in any other class of machine tool, because the lower faces can only be dealt with by milling cutters.

The first illustration, Fig. 484, Plate XLII, shows a number of 10¼-in. connecting rods, mounted, and having both faces of both bosses tooled at the same time by means of straddle mills. The rods are carried on an annular portion of the base, high enough to allow the cutters to clear below. The outer cutter is steadied with a lower stay. The rods are carried between plates. The upper plate of the outer pair is removable to permit of the insertion and unloading of the rods. The outer portions of the outer plates are vee-shaped to locate and grip the bolt lugs on the big ends of the rods.

* The Becker continuous milling machine, in connection with which the fixtures dealt with in the present article are used, was fully illustrated and described in our issue of March 8 last, page 249.

The small ends are secured laterally between triangular top plates, alternately fixed and adjustable, each alternating adjustable plate being pushed inwards over its tightening bolt—the bolt hole being slotted—with a bevelled-edged clamp (one of which is seen clearly at the left of the photograph), thus pushing the rod against the fixed plate adjacent. The loose upper vee'd plates, which are removable for the unloading and loading of the rods, have swivel washers, with slot bolt holes to be easily swung aside, and so avoid running the nuts off.

In the next photograph, Fig. 485, the method of fixing differs in nearly all its details from that of the others. Everything is carried on a substantial base raised high enough for the cutters to clear, and lightened with pockets. The rods, 14 in number, are disposed radially with the big ends outwards. They are laid as closely together as the necessities of the design will permit, the distances apart of the small ends determining the spacing, so that a good deal of cutting wind on the outer radius is unavoidable. The big ends are located all at the same height with vees on the edges of the locating and clamping plates, which, however, are not divided as are those in Fig. 484. A difference will be noticed in each alternate plate. One is short, and held rigidly down to the base with four cheese-head screws. The next adjacent is hinged, so that its two jaws can be moved apart and tightened laterally against two opposed bolt lugs. The jaw openings are covered for the greater part of their length with a thin plate to prevent cuttings getting in. At the small ends the bosses lie on the base of the fixture and are located laterally by triangular blocks, also having forms that alternate. One block is rigid, and a rod lies against it, not directly, but having contact with a narrow strip sunk into its vertical face. The block on the opposite side is adjustable on a pivot to be tightened, to provide for slight differences in the forgings. Each exact radial setting in a case of this kind is not of importance, so that no special provision is made for that beyond the guidance afforded by the ends of the blockings. The feed taken is 4 in. per minute, and an output of 50 rods completed per hour is guaranteed.

In Fig. 486 the rods, tooled at the same rate as the last, are disposed slightly tangentially—a method which is as a general rule to be recommended because it brings the work within a smaller diameter, and thus reduces the distance to be traversed by the tool. It would also be of advantage when the work is being done on a machine with a table of small diameter with reduced support under the cut. As in the previous case the bolt lugs of the big ends are located and gripped in vee-blocks on the edges of the clamping plates. One set of these plates alternates with another set of a different character. On the two outer edges of one plate, vees are cut, and the plate is screwed down rigidly to the base with three cheesehead screws. The plate adjacent has one vee solid with it, but the other is formed on the end of a screw with a pivot and moved with a box spanner. The tightening of the adjustable vee pushes the big end up against the vee in the fixed plate. The webs of the rods lie on pins in the base of the fixture. Both big and small ends project beyond the edges far enough for the straddle mills to clear. The webs near the small ends lie each between a cubical block on one side, and a round pin on the other which locate them, and help to resist the pressure of the cut. A double U-clamp holds down two adjacent rods. The nearly central bolt fits in a slotted boss to permit of sliding the clamp along to clear the bolt, instead of running the nut off to remove the clamp when loading and unloading the rods.

Fig. 487 illustrates a continuous fixture for milling the boss faces of drop-forged hand-brake levers—the four faces of the two bosses being machined in two operations, for which one setting of the levers suffices. The base of the fixture is a casting provided with vertical blocks between which the actual work-holding elements are located, the blocks fulfilling also the function of stops to resist the pressure of the circular cuts. Radially the work-holding bodies are set against shallow abutment blocks, two of which are seen in the space that is unoccupied in the foreground. The bodies are clamped against these stops, each with a screw tapped into a lug in front. The lugs are seen round the base. The construction of the work-holding fixtures can be seen in the one detached in the foreground. The opposed faces of the body and of the cover are cut to the angle of the webs of the levers, two of which are clamped side by side with a wedge-shaped division strip between. They are secured through a single central screw stud and lever nut, with an open-sided washer which is swung aside when the nut is slackened for the removal of the work. Pressure on the levers is taken by hard steel faces at the ends. The straddle cutter seen has a wide space in the upper section to deal with the thicknesses on the larger bosses, and a narrow space in the lower for the smaller ends. The four boss faces are machined in two operations.

The next two photographs, Figs. 488 and 489, Plate XLII, show the first and second operations done on a drop-forged spring shackle, performed in two fixtures, in which six boss faces are finished. The forging is seen lying in front in each view, Figs. 488 and 489.

In Fig. 488, for the first operation, 16 pieces are carried in the annular fixture, two in each of the recesses formed on the internal face, while the four faces, marked on the forging, are milled. Each forging fits by its long continuous boss, the forked end standing out towards the centre. The bosses of the forked end lie in the vee'd edges of bottom and top plates, the first being cut solidly in the division blocks in the fixture body, the second in separate plates attached with set screws. The two bosses are located between the upper and lower vee'd edges, and are tightened against them with the set screws seen disposed radially round the base, which screws carry each a vee-block on its inner end, visible in the upper right-hand portions of the photograph, and which bear against the single boss of the forging. These are tightened up with a box spanner. When the forgings are thus located and set, the clamp plates seen above are tightened, each plate bearing on two adjacent forgings. The screw for each plate has its own lever solid with its box nut. The repetition of details such as this saves time in picking up loose spanners and enables the attendant to unload and load without stopping the machine. The feed is 4 in. per minute. An eye is screwed into the base of the fixture for the purpose of lifting it on and off the machine table. Chips and oil fall down through openings, and are removed through the clear spaces made in the base. The output is 76 pieces per hour, or nearly five complete loadings.

In the second fixture, Fig. 489, where only two boss faces are machined, the capacity is nearly doubled, 28 pieces being mounted, with an output of 82 per hour. Here the inner faces of the double bosses fit over the upper and lower tooled faces of the ring fixture, and against its outside, in order to get the largest number of pieces in. They are located in pairs, right and left of the central clamp screw, and clamp, which bears on two adjacent forgings. The stud bolts are surrounded with coiled springs to throw the clamps off the work on the release of the nut with the box spanner. The fixture is lifted by the central cranked bar.

A fixture for automobile starter covers is shown by Fig. 490, on Plate XLIII. It has an annular base provided with facings, stops, screw clamping lugs, and with flat clamp plates combined with their thickness packings. Both sides of the covers are being faced in alternate series, backs and fronts adjacent.

This is an illustration of a single fixture in which two distinct operations are performed. Fourteen pieces are held with their opposite faces alternating. The first operation is that of milling the square facing, done on seven pieces. For this, the covers rest by their lower faces, rough-cast, on three hardened steel pins. The diagonal disposition of the clamping screws holds the covers down to a bedding, the principle of which is embodied in many clamps. The second operation is being done on the opposite faces of the other seven pieces. For this the castings are located for height on facings which are as much higher above the pins that support the rough castings, as is the depth of the cut to be taken during the second operation. When a casting has been finished on both sides it is unloaded, and its place is taken by an adjacent cover on which the first operation has been performed, and for the latter a rough casting is substituted. One cover is milled on both sides per minute, so that the attendant must change one every 30 seconds. The milling is done with a high-speed steel cutter, 7 in. diameter, making 45 r.p.m., with a feed of 0·13 in. per revolution.

A fixture for the covers of transmission cases is shown in Fig. 491. Two faces are machined in two operations. A cover is seen lying in the waste oil trough. Four castings are set with their joint faces to be tooled, and alternating with these are four others which, having been faced, are set for the milling of the end bosses. The covers that are set with their joint faces upwards are secured in vice blocks, each with a diagonal clamp held with a central stud bolt, encircled with a coiled spring which throws the clamp off the work when the nut is slackened. The clamp takes its abutment against two studs in the vice block. When the covers are reset to have their bosses faced, they are located laterally by means of studs on the vertical faces of the fixture, and in the vertical direction with tall studs that abut against the outsides of the small bosses that stand out horizontally. They are secured to the vertical face with a clamp plate bearing on each flange, which also takes a packing bearing on the sides of the vice blocks adjacent.

The illustration Fig. 492, on Plate XLIV, is that of a milling operation on 16 clutch shifter yokes, samples of which are seen lying in the trough that surrounds the table. The straddle mill faces both sides of the two bosses at one operation—four faces being thus dealt with simultaneously. The shanks of the yokes, previously rough-turned, lie in vee'd recesses in the circular fixture, in which they are secured in pairs with bolts, and triangular clamp plates, the latter being of the three-point bearing type, two of the points making contact with the shanks of the yokes, while the third rests on the body of the fixture. The yokes are located lengthwise at the bottom by vertical stops in the base, at the top with pieces of plate bolted on the fixture. The faces of the bosses are about $\frac{3}{4}$ in. in diameter. They are tooled with four cutters of 6-in. face, rotating at a speed of 110 r.p.m., the fixture having a feed of 10 in. per minute; 195 pieces are completed per hour.

The fixture for the housing of a differential gear is seen in Fig. 493. Except that two castings are mounted at one time on a circular base specially designed, the method of holding resembles that which would be adopted if done directly on a machine table—that of vee-blocks to receive the circular ends of the castings. The blocks are cast with the base, and are so disposed as to carry two castings located in the positions most suitable for tooling their faces within the smallest radius of action of the cutters. The clamping caps are placed diagonally in order to keep them below the milling cutter, and they have slotted bolt holes. Tall abutment blocks making contact with the sides of the castings prevent them from swivelling in their vee-blocks under the pressure of cutting.

The illustration Fig. 494, on Plate XLV, is that of a fixture for carrying trunnion bearings to have their back faces milled. The holes having been already bored afford the means of location for the thickness from the bore to the back face. The bearings are milled in pairs, two each in 16 stations, using a feed of 6 in. per minute, with an output of 140 per hour.

Comparing the three stations in the foreground that are occupied with bearings with the remainder which are unloaded, the following features can be observed. The locating elements are 16 turned pins or mandrels, secured radially in the ring body of the fixture with stems having screwed ends and nuts, set up permanently. At the outer end of each mandrel is a stud and nut by which the work is tightened in the recesses seen cut in the outer vertical face of the fixture. The bores of the trunnion bearings when laid on the turned mandrel pins are further located with abutment blocks that stand up to make contact with the inner or back faces of the bearing flanges, which blocks are seated in the boss pieces seen, these being portions of

the main fixture casting, and alternating with the work. They are of two kinds, one being a plain round pin carrying a hardened abutment stud, the other having a pivoted head with two upstanding horns, which accommodate themselves to inequalities on the bearing castings. The lower portion which carries these pins is a loose block, to which is also screwed the slotted plate which is clamped against the outer bearing face by means of the nut on the mandrel screw. For unloading the work this is lowered to the position of one of the blocks seen at the right hand. For loading and clamping it is raised as seen in all the other blocks. Handles standing out permit of their ready manipulation.

In Fig. 495 the same kind of work is being done, but the arrangement is slightly different. The clutch shaft bearings being treated are held singly on locating mandrels, and are supported on the ends with plain pins, one at each end, and are clamped on the outside with a bolt. The clamp plate and pins are lowered with a lever pivoted on the inside of the fixture. Sixteen pieces are held at one time. A feed of 6 in. per minute is given to the cutter. The output is 70 pieces per hour.

Fig. 496 represents a fixture in which the joint faces of bearing caps are milled. It is built up with as many separate work-holding blocks as there are caps to be treated—20 in number—all mounted on a circular base. Seatings in the blocks receive the caps, which are held down by means of straps, one to each cap, bearing in its concavity, and tightened with the diagonal screws that are seen surrounding the fixture. These screws are eyebolts which are pulled outwards to permit the clamp plates to be thrown up off the caps. Much of the detail in this photograph lies hidden within the clamping blocks. The principal features are these:

The caps to be faced—two being seen at the right hand of the machine—are supported on their oil-cup sides in vee-blocks of hardened steel. These will interchange with other fittings to suit smaller caps which require to be raised higher in the same fixture. The hinged binder strap which clamps a cap down is provided with a loose rocker on its lower face, made concave to render it self-adjusting to inequalities on the cap, acting in this respect like some swivel vice jaws. Spring plungers and studs level the cap.

To unload the pieces, the clamp nut provided with lever handles is swung outwards from the slot in the clamp, and the latter is thrown back to a vertical position, leaving the work clear for removal. The whole of the mechanism is carried in the work-holding blocks, twenty in number, each made separately from the base, and bolted to it from below. The caps are milled with a cutter 4 in. in diameter, making 135 r.p.m., with a feed of 0·125 in. per revolution. The output is 140 pieces per hour.

Fig. 497, Plate XLV, shows a fixture in which drop-forged front spring hangers are mounted to have the faces of the webs milled. The holes have been drilled, and the boss faces tooled. The drilled holes locate the setting through pins in the base. Uprights are cast with the base, against which, through hardened steel strips let in, the edges of the bosses abut, and are clamped each with a single plate and stud bolt. The webs, facing inwards, rest on packings, and their edges are sustained against cutting stress by contact with the edges of hardened discs, carried on pins.

Fig. 498 illustrates a fixture in which sad irons—flat irons—are set to have their faces milled. The tooling fixture receives the castings on packings solid with it, and round stop pins cast with the base have discs of hardened steel on top, against which adjacent castings are located. A separate clamping arrangement is rigged up for each. It is a loose block with slotted bolt holes which permit of its adjustment on the base, to which it fits with a tongue and tooled surfaces. A diagonal clamp abuts against a bevelled face on the block, and carries two tongues of hardened steel which bear against the square ends of the castings, pressing them against the stop pins, and also pushing them down to a bearing on their seatings on the base. A single stud bolt provides the necessary pressure. Nine irons are held, and milled with a feed of 7 in. per minute, and an output of 59 per hour.

FALLING WEIGHT TEST ON RAILWAY TYRES.

By J. H. G. Monypenny.

The principal manner in which railway tyres are tested in this country, and to a great extent in other countries, is by the drop or falling-weight test. In this method, as is well known, the tyre is placed in a running position on a steel block (weighing not less than 5 tons) supported on a rigid foundation, and a tup, generally weighing 1 ton, is allowed to fall freely on to it from gradually increasing heights until the tyre has given, without fracture, a certain minimum deflection, the amount of which depends on the diameter and thickness of the tyre and the class of steel of which it is made.

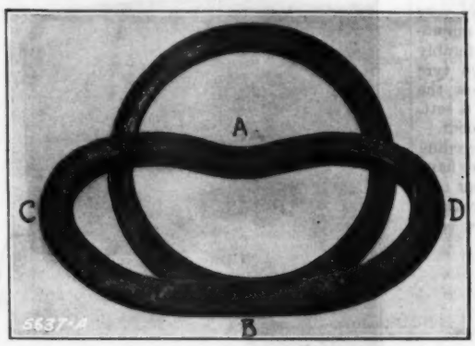


Fig. 1.

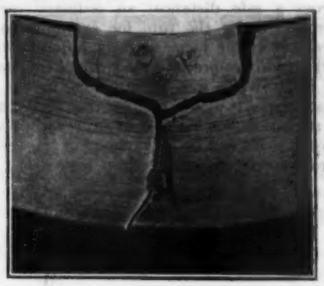


Fig. 2.

Fig. 3.

It is obvious that under this test the tyre is severely distorted in certain parts while in others it is hardly deformed at all. In the part directly under the tup (A in Fig. 1) the steel will be stressed in tension on the inner face of the tyre and compressed on the tread and flange. Similar stresses, though probably not quite so severe, will be produced at B where the tyre rests on the block. At the two intermediate points, C and D, the tyre is under tension and compression on the outer and inner parts respectively. The amount of deformation produced, especially on the inner face at A, is very considerable. When a tyre is tested to destruction it generally breaks at A, the fracture starting on the inner face, running in a direction normal to the surface for about half the thickness of the tyre and then branching off at a sharp angle, often in two opposite directions. The failure of a tyre under these conditions is broadly analogous to the behaviour of a bend test-piece of hard steel which breaks generally along a wedge-shaped outline corresponding to the compressed area (see Fig. 2).

If we assume that the object of drop-testing tyres is to prove the ductility of the steel, then it might be expected that the results of the drop test and the elongation or reduction of area observed in the tensile test would be in some way related. No such relationship, however, has been established nor, indeed, does any exist. If the object of the drop test were to prove the reliability of the tyre as a whole, then clearly the results are influenced by the pure chance of any weak part of the tyre happening to be in a position such as A, B, C or D (Fig. 1), where it will be stressed greatly or in some other position where it will be stressed in a lesser degree.

That some part or parts of a rolled tyre are weaker, or less able to withstand distortion than others is a fact which may be confirmed by whoever will take the trouble to examine the materials and methods of tyre making. Tyres are usually made from octagon ingots. As a matter of convenience we reproduce in Fig. 3 a photograph of a square ingot and it will be noted that towards the top, the surface of the ingot is rough and folded on itself. A billet or bar or tyre or any other object rolled from the rough part of the ingot would have an imperfect surface; it would be shelly and roaky. Just under the surface of the ingot, beneath the folds, small holes would probably be found if the ingot were cut lengthwise. The surface of an ingot may be folded or pitted for a variety of reasons and for similar or entirely different reasons small holes may occur in an ingot immediately below the skin. We are not, therefore, justified in regarding the rolled tyre as free from surface defects or irregularities, and as it is not a matter of indifference to the results of drop-testing whether the defects happen to occur in the heavily or lightly deformed parts, so the drop test may mislead us into rejecting tyres which are actually better though by pure chance they appear to be not as good as those accepted.

The defects which may be looked for on the outer surface of tyres in the rolled condition are small seams due to subcutaneous blowholes, roaks or shelliness due to rough ingot surfaces and laps due to negligent forging. Similar defects might be found on the inside surface of the tyre, but they rarely occur there unless badly piped ingots are used. By way of illustration attention may be confined to small seams which penetrate to a small extent radially into the tyre. Such seams may be regarded as notches of the worst kind. They are dangerous because they are at least incipient cracks, and, as everyone knows, it is more difficult to start a crack than to extend one which already exists. In tyre steel, which contains from 0.5 per cent. to 0.7 per cent. carbon, this axiom holds more than in milder structural steels. To give some concrete idea of the very great effect of a very small notch on resistance to shock stresses, small bars, 0.45 in. in

diameter, were turned from tyre steel. The first bar was not notched. The second bar was notched on one side only to a depth of 0.013 in. Other bars were notched similarly to the depths stated below. The bars were gripped in a vice and broken by the impact of a pendulum hammer as indicated diagrammatically in Fig. 4. (Izod test.) The energy absorbed in breaking the bars is shown below (the unnotched bar bent over but did not break).

Depth of Notch.	Energy Absorbed in Ft.-Lb.
Unnotched	200
·013 in.	23
·030 ,,	16
·062 ,,	7
·125 ,,	3

A comparison of the first two lines shows very forcibly how sensitive this steel is to even a minute notch—and, indeed, anyone who has seen (preferably from a safe distance) an ordinary carriage tyre broken under the tup, for example, to show the fracture, after being slightly notched with a sett, will readily appreciate the truth of this statement.

From what was been stated in the preceding paragraphs it will be realised that should a tyre have a surface defect which is in any way equivalent to a notch there will be a likelihood of the tyre breaking prematurely under the drop test if the part containing this defect should happen to be situated in one of the highly-stressed areas shown in Fig. 1.

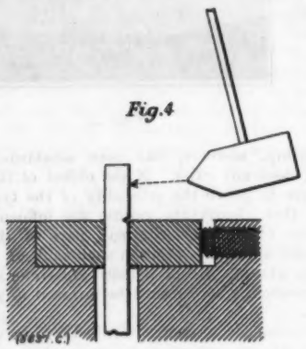


Fig.4

During the past fourteen years the writer has had many opportunities of examining tyres which have failed under the drop test, and has noticed repeatedly how small a defect is required, providing it happens to be in the right (or should it be wrong?) place, to cause a high tensile steel tyre to break. Figs. 5 and 6 illustrate this point quite well. These tyres failed under test, fracturing directly under the tup, and the appearance of the fractures left no room for doubt that the small flaws seen in the photographs at A had caused the premature breaks. The flaw shown in Fig. 7 occurred on the tread of the tyre, and the latter broke in position C (Fig. 1) through this flaw. In each of these three cases the tyre was perfectly good except as regards the flaw and one could be quite sure if the defects had not been present or if the tyre had by chance been rotated through an angle of 45 deg. before testing, so that the defects were in the unstressed parts of the tyre, the test would have been successful.

It is, of course, the aim both of the steel-maker and the tyre-maker to produce an article as free as possible from defects, but it is impossible to avoid always the occurrence of such things as small blow-hole segregates under the skin of an ingot (Fig. 7), small laps in forging or rolling, slag occlusions (Fig. 5), cracked edge in forging (Fig. 6), or other similar small imperfections.

The question as to what influence such flaws as these would have on the life of a tyre if they were undisclosed by the drop test, as frequently happens, can be answered very easily. Carriage and engine tyres are machined on the inside and on the tread and flange, and in many cases all over before being put into service and such flaws as those in Figs. 5 and 6 would be completely removed during this operation. The one shown in Fig. 7 is rather larger and might not be completely removed, but in this case the part remaining would be visible on the machined surface. It is also perfectly obvious that if the tyres containing these flaws had been machined to finished sizes before the tyres were tested the latter would have stood the drop test quite successfully.

Fig. 5.

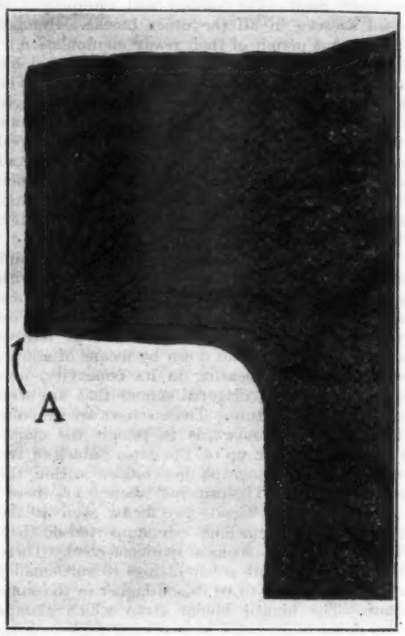


Fig. 6.

Fig. 7.

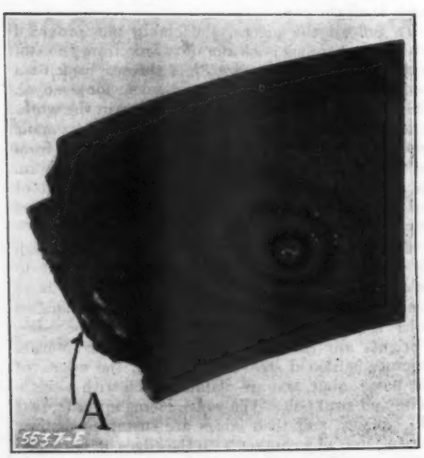


Fig. 8.

Is it quite equitable that a tyre should be drop-tested in the rolled condition with the sins of the ingot and every other neglect or defect of manufacture on its surface? If it were put into service in that state it would not be unreasonable to test it as a whole in that state. It is, however, machined on the inside and on the tread and flange at least before it is stressed in service. Every steel-maker knows that he may not quench high tensile alloy steel even in the simple form of bars without first machining either from the bloom or bar the outer parts containing ingot surface defects, and the drop stamper likewise may not safely distort the material, even in the heated state, unless a similar precaution has been taken. In each of these cases the stresses are less violent and the distortion not more sudden than those applied to tyres by the falling weight. It is therefore equally desirable at least that surface defects should be removed from a tyre before testing, particularly as such defects are incidental and are machined off before the tyres are put into service. If it were proposed that the tensile test-piece cut from a tyre should be a flat bar machined from the front of the tyre and having as one of its flat surfaces the actual skin of the tyre, a storm of protest would be raised, and one would hear very forcible remarks as to the value of the results obtained from such a piece; and yet, such a test would be quite as logical (or illogical) as the present method of taking the drop test on the unmachined tyre.

The writer would very strongly urge that the drop testing of tyres should be done in such a manner that the tyre is tested in the condition in which it is put into service. The only possible objection to this proposal is that the machining costs would be wasted

if after all the tyres failed to pass the drop test. This objection could be met by giving the steel-maker the option of presenting machined tyres either in the first instance or after failing to pass in the unmachined condition. In this way one would save the scrapping of good material which now takes place owing to the hazardous influence of small surface defects which can have no possible effect on the life of a tyre since they are removed before it is put into service.

There is another type of flaw—in this case put into the tyre intentionally—the effect of which on the strength of the latter is very often overlooked. The potential flaw referred to is the series of stamp marks on the front of the tyre. One can quite understand that it is necessary for the railway companies to identify the tyres they put into use, but whether it is necessary to have the life history of the tyre from its infancy (as molten steel) onwards stamped in $\frac{1}{4}$ in. letters round its face, is perhaps questionable. Such descriptions, for example, as "Siemens Acid Open-Hearth Steel" (as was specified in one case) seem redundant. As it has been already pointed out that steel used for tyres is easily broken when notched, it would seem advisable to avoid lettering as far as possible. By suitably placing the tyre for the drop test one can generally arrange that these deep stamp marks shall be in the parts only lightly stressed, but it occasionally happens that owing either to the small size of the tyre or the length of the descriptive stamping on it that this is impossible, and in such cases the fracture may be materially helped by the deep stamp marks as it was in the instance illustrated by Fig. 8.

In this type of flaw one is not only liable to get a bad effect on the test obtained but also on the life of the tyre, as these stamp marks are not removed during machining but remain as very favourable places for the starting points of cracks. Also their effect on the tyre is likely to increase with the increasing hardness required from tyres. The writer is not aware whether failure of tyres in actual service has ever been traced to letter marks, but he has seen numerous cases of failures from this cause under the falling weight test when through oversight or force of circumstances the lettered part of the tyre was allowed to occupy position A, B, C or D (Fig. 1) in the distorted tyre.

STATE ELECTRICITY, ELECTRICITY SUPPLY COMBINES, &c.

It is interesting to watch the growing attention which the Governments of different countries are bestowing upon the increased production and distribution of electric energy. Even the British Government has gone to the length of appointing a committee to consider the subject, and has published its report. This, however, is a very small exhibition of activity when compared to what has been done on the Continent.

In most German States the development of electric power stations is more to the fore than ever, and the various States separately, and even the Empire, are taking an active share in this movement. At present some 74 per cent. of the area of Germany may be said to be supplied with electric energy, and the supply is being planned for an additional 18 per cent., a balance of only 8 per cent. being unprovided for. The latter area is principally to be found in the provinces of Posen and Silesia.

Of the different German States, Würtemberg and Saxony have advanced the furthest as regards the supply of electric energy to each house, and within these countries there are only very few districts which are without the advantage of electric supply. The connection of the different power stations in Würtemberg for the purpose of mutual support and assistance is almost completed, and in Saxony the connecting process is in progress. In Baden and Bavaria, owing to the absence of fuel within these countries, special attention has naturally been devoted to the exploitation of available water power. In Bavaria the country left of the Rhine has been adequately opened out by the Pfalz power station, whilst on the right side of the Rhine a number of hydro-electric and steam power stations have been co-operating for several years, amongst them the Munich and the Augsburg centres. An impending utilisation of the substantial power of the Walchenoll, in which the Government is much interested, will materially increase the supply of electric energy; it is proposed to connect the existing distribution systems, and hydro-electric and steam power stations will co-operate in the working of the scheme. Baden has the advantage of having the Rhine over a long distance for its boundary, and this river, with one of its tributaries, supplies the bulk of the power for generating electric energy. There are, however, several small unprovided districts, but the large Murg hydro-electric power station, in Central Baden, will facilitate the coupling of the different electric power stations.

As far as Alsace–Lorraine are concerned, there are in the south three large central stations—Mülhausen, Schlettstadt and Strassburg—which are connected with each other. Lorraine obtains her supply from power stations at Metz, Saarbrücken and other places, but a considerable district is still unprovided for. Lorraine contains coal, and there is water power of considerable capacity available between Basle and Strassburg, on the Upper Rhine.

The Grand Duchy of Hesse possesses a number of municipal steam power stations which, so far as it is at present feasible, supply the country with electricity and there are but few localities unprovided for. The same may be said to apply to Mecklenburg Schwerin, to Mecklenburg Strelitz, to Oldenburg and Brunswick. In the Thuringian countries there are several stations which supply the greater part of the States, more especially the industrial centres, with electric energy. Some mountainous districts have not been provided for owing to the limited demand.

In Prussia the development of central stations has so far proceeded without any State influence of importance having been brought to bear upon it, and the ministerial decree of May, 1914, has not made itself much felt. In spite of this inactivity of the State as regards the general supply of electric energy, on the whole an adequate supply has been provided, excepting as far as the frontier provinces are concerned. In the provinces of Brandenburg, Hanover (where the State is now stepping in), Sachse, Rhineland and Westphalia, there are a few blanks, mostly owing to their thin population. The province of Schleswig-Holstein has only one central station of importance in the south-eastern part of Holstein, and a smaller one at Altoria.

As regards the unprovided portions of Prussia it has been stated above that their supply with electric current, to a great extent, has already been planned. The province of East Prussia, by means of State aid, will be fully opened out in order to make good the sufferings from the war. In this connection the large peat deposits of the province may be destined to play an important part. Whether the scheme will prove a financially satisfactory undertaking is only of secondary importance in this connection, and this naturally facilitates the realisation of the project on a large and comprehensive scale.

The portions of Prussia which are really in need of electric supply are the agricultural districts on the eastern border, West Prussia, Posen and, to a smaller extent, Silesia. The provincial authorities, through the utilisation of the water power of the Oder district, have seen to the western parts of the province. In the coal districts there are several large central stations which would probably have further extended their systems, had the prevalent conditions favoured such developments.

The expansion of the distribution and supply of electric energy in Germany has proceeded at an extremely rapid rate. According to available material only 28 per cent. of the aggregate area was provided with electricity in 1910, against 74 per cent. at the present time, so the figures representing districts provided and districts unprovided for have been about reversed during that period. Of Germany's 67,000,000 inhabitants at the beginning of the war only about 10,000,000 were without the advantages of electric supply. The number of inhabitants, provided with electricity, rose from 8,000,000 in 1895, to 17,000,000 in 1902, 25,000,000 in 1907, 40,000,000 in 1911 and 50,000,000 in 1913. The Prussian State has proposed to provide for a broad strip of country from Bremen to the Maine. Through the combination of the State hydro-electric power stations on the Maine and the municipal station of Offenback, and the latter's connection with the Darmstadt electricity works and further with the Upper Rhine Railway Company, Mannheim, and the Murg hydro-electric power station, later to be connected with the power stations on the Upper Rhine, a continuous distribution system will be established from Bremen to Basle. The least pleasing feature in this ambitious scheme appears to be the fact that in support of the hydro-electric power stations a large State steam station is needed at Hanover which will entail an expenditure of some 13,000,000 marks, and the financial success of which appears to be somewhat problematic.

In the province of Sachsen the Provincial Legislature has authorised the "Provincialverband" to take over shares, to the value of 2,510,000 marks, in the new electricity concern, Sahsen–Anhalt, to take over shares to the value of 1,840,000 marks in the distribution concern of Südhurz, near Bleicherode and to take over shares up to an amount of 3,000,000 marks in other undertakings intended to further the supply of electricity. Altogether the so-called mixed arrangements between State or province and municipalities and private concerns have a good many supporters in Germany.

In Bavaria the further exploitation of the country's water power is very much on the *tapis*, and large projects are in the process of being developed under the most favourable auspices. Two companies have been formed for the utilisation of the water power of the Upper Inn and the Middle Isar, which names also constitute the style of the two companies in question. A number of Bavarian and Prussian banks are interested in both undertakings, as are also the Schuckert Electricity Company, the Metal Bank and Metallurgical Company, Frankfort, and the chemical concern of Griesheim–Elektron, Frankfort. In the latter company interests are held by the Fried. Krupp Company, Bavaria, and the Fried. Krupp Company, Essen. The capital of each company, so far, is only nominal, viz., 100,000 marks. Another large hydro-electric power station is being prepared in Bavaria, Herr Hromadnik having secured a concession in connection with the exploitation of the falls at Vilshofen and Passau. The capacity is estimated at 45,000 kw. to 48,000 kw., and the energy is principally intended for chemical industries.

The newly-formed Bayernwerke Company is a mixed industrial undertaking in which the State, the towns interested and the existing stations all take part. The capital in the first instance has been fixed at 10,000,000 marks, it being proposed to raise further capital by loans. Of the 10,000,000 marks in shares the State of Bavaria takes over 5,100,000 marks, so that the State has a controlling interest; of the remaining capital the towns of Münich, Nüremberg and Augsburg each take 400,000 marks. The State has the option of taking over the concern at the end of fifty years at a price which represents the cost of the first installation and subsequent extensions subject to a reduction of 1 per cent. per year. In addition to those already mentioned the following concerns are interested in the Bayernwerke Company: The Isarwerke Company, Münich; the Amperwerke, Münich; the Upper Bavarian Overland Central, Münich; the Lech Electricity Works, Augsburg; the Franken Power Station, Nüremberg; the Frankish Overland Works, Nüremberg; the Bavarian Overland Central, Regensburg; the Allgemeine Elektricitäts Gesellschaft, Berlin, as anticipated contractor for the Overland Company, Lower Bavaria; the Electricity Supply Company, Berlin, as anticipated contractor for the Overland Company, Oberfranken West, and also for the Bavarian Electricity Supply Company, Beyreuth; the Schuckert Company, Nüremberg, as anticipated contractor for the Overland Company, Unterfranken Ost; and the Electric Power Supply Company, Mannheim, as anticipated contractor for the Unterfranken-West Overland Company.

The distribution system is to have a pressure of from 100,000 volts to 150,000 volts, and is to

command the whole of Bavaria in a ring from Kochel, over Münich, Augsburg, Nüremberg, Würzburg (with a branch line to Dettingen), Schweinfurt, Bamberg, Bayreuth, Amberg, Haidhof, Regensburg, Landshut and back to Münich and Kochel. It is proposed to carry out the work in four stages and the cost is calculated at 78,000,000 marks.

In Austria matters as regards the electrification of the more important railways have been left in abeyance so far, although the country boasts a great wealth of available water power. It is not for want of preparatory labours that the question has been allowed to drag, and the recent Government seemed anxious to see the problem advanced, for which purpose reports have been published of the comprehensive work which actually has been carried on at the instance of the Austrian Railway Department and which extends over a series of years. It transpires from these reports, that no less than 433 falls, with an average annual yield of 1,500,000 kw., have been surveyed with a view to exploiting their power, and of these 17 have been secured through fully legal concessions and 7 additional concessions are pending. The aggregate of these 24 concessions represents an annual average of 135,000 kw. In addition, the State Department has exercised its right of option in 16 cases, in which water power concessions had been granted to private concerns, and in 37 cases steps for utilising the right of option has been taken in hand. Further reports with more detailed particulars will be published in due course.

Of the plan for the electrification of the main railway lines, or perhaps rather ordinary gauge railways, two projects have received special attention, viz., the line Steinach–Irdning–Attnang–Puchheim and Arlberg section. The former scheme had already been guaranteed current by the War Ministry from the Gosau station. Upper Austria was ready to find the capital and the State Railway Department only had to undertake the payment of interest on the capital and sinking fund from the revenue. Everything, in fact, was in order, when difficulties unexpectedly cropped up in the eleventh hour.

As regards the electrification of the Arlberg line, the whole section, Innsbruck–Bludenz, was surveyed, and everything seems to favour this scheme, including the steam traction trouble in the Arlberg tunnel, the comparatively large traffic, the high cost of fuel on account of the considerable distance from any coalfields, and the fact of several admirably suited waterfalls being available. But in spite of all these favourable conditions which, both from technical and financial considerations, would seem to make the electrification of this section a foregone conclusion, nothing came of the scheme before the war, and at the present moment its realisation is out of the question, although the war to a marked degree has emphasised the desirability of its speedy consummation.

Some large hydro-electric power stations have in the meantime been planned, and the necessary concessions granted to or applied for by private persons or companies. Thus Count Armin Mikes has secured the concession to exploit the power of the Talabor River. The capacity of the power station in question will amount to 22,500 kw. to 30,000 kw., the energy being intended for large industries owned by Count Armin Mikes. A larger scheme is that promoted by a syndicate for the exploitation of the power of the Wallsee, on the Danube, to be effected north-east of Mitterkirchen; the full capacity amounts to 120,000 kw.

No Government has probably shown more initiative and more foresight in this connection than that of Sweden. We have at different times dealt fully with the three large Swedish hydro-electric power stations so far completed, and it is satisfactory to be able to record that in every respect they work exceedingly well. The ever-increasing demand shows that the prices charged are reasonable, and yet the financial result leaves no ground for complaint, as will appear from the following figures. The capital invested is as under, in millions of kroner*:—

—	1911	1912	1913	1914	1915	1916	1917	1918
Trollhättan	18·4	21·0	23·6	26·4	28·6	32·2	38·5	45·0
Porjus	—	—	—	—	12·8	13·4	14·5	15·5
Alfkarleby Västeras ..	—	—	—	—	—	16·3	21·0	26·0
	18·4	21·0	23·6	26·4	41·4	61·9	74·0	86·5

After providing for renewals, and all working expenses, &c., having been deducted, the yield from the State hydro-electric power stations, the steam power reserve station at Västeras being taken jointly with the Alfkarleby station, will appear from the following table, the figures representing millions of kroner:—

—	1911	1912	1913	1914	1915	1916	1917	1918
Trollhättan	0·66	0·71	1·13	1·40	1·70	2·41	2·70	3·10
Porjus	—	—	—	—	0·55	0·67	0·70	0·80
Alfkarleby	—	—	—	—	—	1·13	1·45	1·70
	0·66	0·71	1·13	1·40	2·25	4·21	4·85	5·60

Or, in percentage of the capital invested, as per the preceding table:—

	3·58	3·38	4·79	5·30	5·43	6·80	6·55	6·48

The capacity of the above power stations has increased from year to year, as will appear from the subjoined table, in which the figures represent thousands of kilowatts:—

—	1910	1911	1912	1913	1914	1915	1916	1917	1918
Trollhättan ..	34	34	51	60	68	68	68	86	114
Porjus	—	—	—	—	36	36	36	36	46
Alfkarleby ..	—	—	—	—	—	30	50	50	50
Västeras ..	—	—	—	—	—	—	—	14	28
	34	34	51	60	104	134	154	186	238

The maximum output delivered was as under, the figures representing thousands of kilowatts:—

—	1910	1911	1912	1913	1914	1915	1916	1917	1918
Trollhättan ..	16	21	29	34	40	49	66	71	86
Porjus	—	—	—	—	16	16	16	20	28
Alfkarleby ..	—	—	—	—	—	14	32	37	43
	16	21	29	34	56	79	114	28	157

The energy supplied during the different years, in millions of kilowatt-hours, was as under:—

—	1910	1911	1912	1913	1914	1915	1916	1917	1918
Trollhättan ..	31	97	120	199	220	279	366	475	530
Porjus	—	—	—	—	—	24	30	50	80
Alfkarleby ..	—	—	—	—	—	23	120	160	190
	31	97	120	199	220	326	516	685	800

The State electric power stations in Sweden now produce about one-third of the aggregate amount of electric energy produced in the country. Their distribution lines, carrying 10,000 volts and more, represent about one-third of the aggregate, and the State power stations supply an area on which live about 30 per cent. of the country's inhabitants.

A proof of the impetus given to industrial developments by ample supplies of electric energy is seen at Stallbacka, where a number of industries have been started during the last few years, based upon the energy obtainable from Trollhättan. The low-water volume in the Göta River in an exceptionally dry year may be put at 325 cub. m. per second, but as a rule a minimum of 375 cub. m. per second may be reckoned upon. The highest consumption of water at the Trollhättan power station in 1917 was estimated at 300 cub. m. per second, or 90 per cent. of the volume of the average water in the river.

In the same way as the Trollhättan power station supplies by contract electric energy to other power concerns, the Gullspang–Munkfors Power Company, for one, and the Ynggeredsfors Company for another, so the Alfkarleby power station has entered upon a contract with the Oreloesund iron works, but this arrangement is of a reciprocal nature. The Alfkarleby station now supplies power to the large new Oreloesund iron works because, for the time being, only one blast furnace is in operation and the gas supply might be interrupted, but when in full swing the iron works will have a surplus of gas, and hence of power, which will then be taken over by the Alfkarleby power station. The connection of the power plant at the iron works to the State electricity system will supplement the working of the gas engines, which do not lend themselves to much overload. This is the first instance of the Royal Waterworks Board having come in touch with a concern which both wishes to receive and to dispose of power. Comprehensive schemes are, however, being formulated with a view to establishing a mutual give-and-take arrangement among private power stations. There is, also, a likelihood of the power stations on the Eskilstuna River being coupled with the Alfkarleby system, in which case the former will be specially used to deal with the day load. It is under consideration to regulate Lake Hjälmaren so that its water may be available when the Dala River is low.

At present a volume of water amounting to 225 cub. m. per second is being utilised at the Alfkarleby power station, and it is only during holidays and the following nights that there is a surplus of water. The load at the Alfkarleby power station is singularly uniform. The primary power, that is the power which can be relied upon at all times, both day and night, is being utilised during about 5,800 hours per year. The reservoir above Alfkarleby is ample for equalising the variations between day and night. Based upon previous experience the steam power requirement (from the Västeras reserve) has been carefully calculated. Prior to the regulation of the Dala River and during a year with the normal volume of water and a primary power output of about 35,000 kw. it amounted to some 28,000,000 k.w.h., or about 11 per cent. of the total output of the power station under the same conditions. After the regulation of the Dala River the steam power output will be reduced by some 15,000,000 k.w.h. to 20,000,000 k.w.h

At the Porjus power station two of the units are reserved for electric traction on the Riksgränsen Railway, and the third unit supplies energy to the mining undertakings at Gellivare and Kirunavaara and to newly-erected iron works at Porjus. After the regulation of the Luleälven there will be a low-water volume at Porjus of about 60 cub. m. per second available, whilst the consumption does not exceed 35 cub. m. to 40 cub. m. per second; there is consequently a margin of 20 cub. m. to 25 cub. m. per second for additional future load.

The Swedish State hydro-electric power stations have hitherto been and are likely, as far as natural conditions will allow, to remain in a state of continuous evolution. At the Trollhättan the third instalment, of 13 units, is expected to be ready for use towards the close of the present year. This means plant of 105,000 k.w. capacity, exclusive of reserve, and exceeds the power requirements of the current year by some 19,000 kw. This should suffice for the next few years, say, to 1921 or 1922, provided that no exceptional measures are introduced for supplying electrochemical industries with primary power and that secondary power, that is power in excess of the power which is always available, is only supplied to this industry on a limited scale. There may for some time to come be certain difficulties at low water, but an arrangement with the steam reserves of the city of Gothenburg and the Ynggeredsfors Company would make the Trollhättan power station fairly independent of a decrease of the volume of water below some 340 cub. m. to 350 cub. m. per second.

The best means for making Trollhättan more independent of shortage of water, and for increasing its capacity, is the regulation of Lake Vänern. As a beginning it is proposed to regulate the outflow by the week, according to the power requirements, without altering the average. This would only affect the water level in Lake Vänern 1 m., and would increase the primary power at Trollhättan from about 72,000 kw. to about 85,000 kw., so that only 20,000 kw. of the available aggregate power of 105,000 kw. need be disposed of as secondary power. It is probable that it will some day be expedient to employ almost all the primary power of the Göta River for motors and lighting, as by degrees the electro-chemical industry is removed to places where electric energy is in less demand for other purposes, and this fact, coupled with possible

* At normal rate of exchange 18 kroner = 1*l.* sterling, and 1,000,000 kroner = 55,555*l.*, or 18,000,000 kroner = one million sterling.

requirements for electric railway traction, if such can be undertaken, will no doubt necessitate an enlargement of the power stations.

Co-operation between Trollhättan and the steam reserve at Västeros has already been touched upon, but a more comprehensive co-operation between Trollhättan and the Älfkarleby power station is considered advisable. The variations in the volume of water in the Göta River and in the Dala River present great differences, inasmuch as the average volume per month is almost the same for all the months of the year in the Göta River, whilst it varies greatly in the Dala River with its shortage of water during the winter months, a feature common to rivers in more northern latitudes. Without any special regulating work at Lake Vänern there is, at times, a surplus of water in the Göta River during some months, when Älfkarleby experiences a certain shortage. Without going into too many details it may suffice to state that the Royal Waterfalls Board look upon the Göta River power stations not only as a local supply for West Gothland and Bohnsläu districts, but as an equalising accumulator of water power for large portions of Sweden.

At the Porjus power station a new unit of 10,000-kw. capacity is now being installed, and as the electrification of the Gellivare–Porjus Railway is not likely to take place within the very near future, it is proposed to install another unit, like the one referred to, of 10,000 kw. maximum capacity, for industrial purposes, and this will complete the present power station. In this case 18,000 kw. of three-phase energy will be available for new industries, which energy would even ually be classed as primary power, but which for some time to come could partly be disposed of as secondary power. The three-phase lines to Gellivare and Kiruna are so dimensioned that they, without any alterations, can be used for the transmission of twice the amount of energy which, according to the present contracts, has to be supplied to those places, and the transmitting capacity can eventually be increased to four times the amount now contracted for. It would, however, be a mistake to confine the supply of energy from the Porjus station to the localities mentioned and to its more immediate neighbourhood, for the development of the industries concerned, based upon iron ore, charcoal, phosphate, cellulose. In order fully to answer its purpose the Porjus power station must also be able to supply energy to the coast through a transmission line to Lulea, and this line must be so dimensioned that it can be adopted for the transmission of at least 50,000 kw. The rising prices of charcoal will probably cause electric iron smelting to be adopted on a large scale along the coast of North Sweden, and the electrification of the Gellivare–Svartön Railway is not likely to be long delayed. It is, therefore, desirable that the Porjus power station should be enlarged to contain eight units, and the Lule River regulated. The State, however, owns a number of other important falls on the Lule River, the famous Harspranget, the Ligga Fall, the Porsi Fall and the Ede Fall, representing an aggregate of some 2,000,000,000 k.w.h. to 3,000,000,000 k.w.h. per year, which later can be exploited with advantage.

(To be continued.)

THE DESIGN AND CONSTRUCTION OF DIESEL ENGINE FUEL PUMPS.

By G. L. Kirk.

The functions of the fuel pump of a Diesel engine are to deliver the oil fuel to the injection valves on the cylinder and to control the speed of the engine to suit varying loads by regulating the quantity of oil delivered. The oil has to be delivered to the injection valves against the pressure of the blast air, which varies between 750 lb. to 1,000 lb. per square inch. At the same time the volume of oil which has to be delivered is very small, and the variations between full load and no load almost minute, so that it can be understood that the mechanism must be extremely sensitive. To ensure satisfactory results under these conditions, both the design and the workmanship must reach a very high standard.

In multi-cylinder engines the following different arrangements are adopted by various builders of Diesel engines in connection with the general scheme of distribution of oil to each cylinder.

1. One fuel pump, which delivers oil to a common fuel pipe from which the oil is delivered to each injection valve through a distributing box on each cylinder. These distributing boxes contain a metal diaphragm perforated by a small hole, each one being graduated during the trials of the engine so as to ensure the same amount of oil being delivered to each injection valve, each diaphragm having a different sized hole to compensate for the drop in pressure in the common pipe due to the varying distance of the diaphragms from the source of supply and to internal friction, &c. This method involving as it does only one fuel pump is cheap to construct, and embraces the minimum number of valves and glands to keep in order; but the system is seldom adopted in modern engines owing to the difficulty of obtaining an even distribution of fuel to each cylinder, especially at varying loads, the result being that the work is not divided evenly between the cylinders.

2. The second method adopted by a few designers is to supply a separate fuel pump to each cylinder. This system ensures a perfect adjustment of the supply of oil fuel to each injection valve, but necessitates a somewhat cumbersome and complicated driving and control gear, and is seldom made use of in modern engines.

3. The third system is a direct modification of the last one, all the pumps being cast *en bloc* and each plunger driven by a separate eccentric or crank through an overhead crankshaft, each crank being set in its correct relative position to the main engine, so that the pumps deliver the fuel at the correct period of the stroke. This arrangement is very neat, convenient and accessible; the pump can be placed in the most suitable position, and the control gear is simple. This system is almost universally used on all large marine engines.

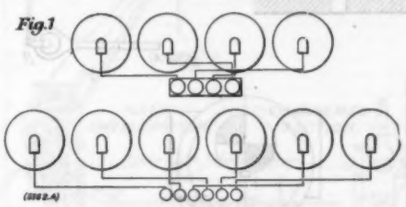


Fig. 1

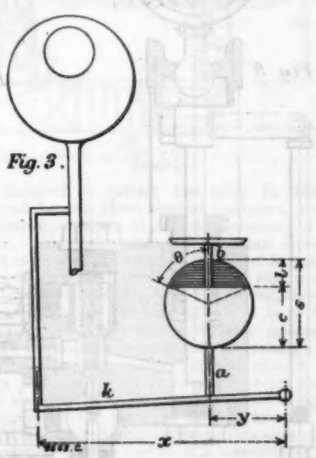


Fig. 3.

4. The fourth system consists again of the pumps all being *en bloc*, one for each cylinder, but the plungers are driven from a common cross-head in the case of three or four cylinder engines, and in groups of three from two cross-heads in a six-cylinder engine; sometimes in the case of four-cylinder engines, the plungers are in two groups, driven by two cross-heads; in the latter cases one group is on bottom centre, while the other group is on top centre. The pipe connections are shown diagrammatically in Fig. 1 for a four-cylinder engine, and a six-cylinder engine. This system simplifies the driving gear, only one or two eccentrics being needed, but care must be taken that no pump is delivering its charge while the fuel injection valve is opening. The control gear is also simple and convenient in this case, and the system is usually employed on small engines.

System of Regulation.—Practically the same method of controlling the fuel delivery is adopted in every make of engine. Upon first considerations it might be thought that the volume of the pump delivery could be regulated by varying the stroke of the plunger, in which case the maximum quantity of oil required would constitute the total plunger displacement; but this is not practical, due to the very small quantity of oil required, which would necessitate an extremely small plunger with a very short stroke, in which case a small air bubble under the plunger would prevent it pumping; besides this, there are other obvious disadvantages.

Taking the case of an engine developing 50 h.p. per cylinder at 300 revs., with a fuel consumption of ·42 lb. per h.h.p. per hour, the quantity of oil for one stroke of the pump would be

$$\frac{50 \times 0.42}{60 \times 150} = 0.0023 \text{ lb.} = \text{approx. } 0.07 \text{ cub. in.}$$

The method which is adopted is as follows: The pump is designed to deliver three or four times the quantity of oil required, but the suction valve is held open by

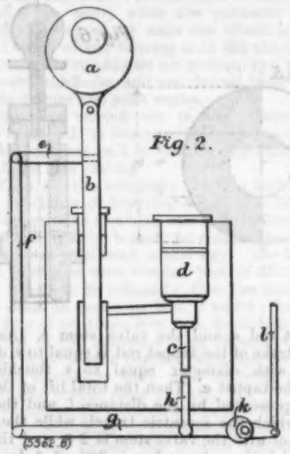


Fig. 2.

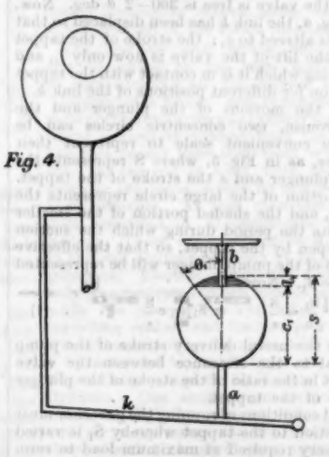


Fig. 4.

means of a tappet attached to the regulating lever for a certain portion of the delivery stroke, the excess oil being pumped past the suction valve until the latter is allowed to close by the controlling mechanism, when the useful stroke of the plunger commences, and oil is delivered to the injection valves. The quantity of oil delivered is varied by altering the period during which the suction valve is held open, thus regulating the useful stroke of the plunger.

A diagrammatic sketch of a fuel pump and control mechanism is given in Fig. 2. The plunger *b* is driven by the eccentric *a*; *c* is the suction valve and *d* the delivery valve. Rigidly attached to the plunger is an arm *e*, by means of which the tappet *h* receives its motion through the links *f* and *g*. It will be seen that when the plunger *b* is at the top of its stroke, the tappet *h* will also be in its highest position, holding the suction valve *c* off its seat. As the plunger moves down, the tappet *h* will also receive a downward displacement, until it clears the suction valve *c*, when the remainder of the stroke will deliver the oil past the valve *d*. The point of the stroke at which the suction valve *c* closes upon its seat depends upon the initial clearance allowed between the tappet *h* and the valve stem. To vary the closing point of the suction valve *c*, and hence the quantity of oil delivered by the pump, the clearance between the tappet *h* and the valve stem must be varied. This is effected in the following manner. The link *g* is attached at its fulcrum

to an eccentric shaft k, this eccentric deriving its necessary displacement from the governor or control handle through the link l and a bell crank lever, so that as the fulcrum point k is displaced up or down the clearance between the tappet h and the valve is varied.

Determination of Clearances.—In order to derive the necessary clearances between the tappet and the valve stem, we must analyse the motion of this mechanism a little more closely, and the following explanation has been derived from the method given in the work of Ignatius Supino, "Land and Marine Diesel Engines," to which the author acknowledges his indebtedness. Referring to Fig. 3, the plunger is at the bottom of its stroke and the suction valve is on its seat, then c is the clearance between the tappet rod a and the valve stem b. Assuming that the stroke of the tappet rod is equal to s, describe a circle with diameter equal to s touching the point of the tappet a. Then the total lift of the valve will be represented by the distance l, and the angle through which the eccentric travels while the tappet is in contact with the valve stem is 2θ, and the angle during which the valve is free is $360-2\theta$ deg. Now, referring to Fig. 4, the link k has been displaced so that the clearance is altered to c_1; the stroke of the tappet is still s, but the lift of the valve is now only l_1, and the period during which it is in contact with the tappet is $2\theta_1$, and so on for different positions of the link k.

Now, since the motions of the plunger and the tappet synchronise, two concentric circles can be drawn to any convenient scale to represent their relative strokes, as in Fig. 5, where S represents the stroke of the plunger and s the stroke of the tappet. The shaded portion of the large circle represents the suction stroke, and the shaded portion of the smaller circle represents the period during which the suction valve is held open by the tappet, so that the effective delivery stroke of the pump plunger will be represented by the distance S_1. Now,

$$\frac{S_1}{c} = \frac{S}{s} \quad \text{or} \quad S_1 = c\frac{S}{s} \qquad (1)$$

That is to say the useful delivery stroke of the pump is proportional to the clearance between the valve and the tappet in the ratio of the stroke of the plunger to the stroke of the tappet.

To satisfy all conditions of running the governor must transmit a motion to the tappet whereby S_1 is varied from the delivery required at maximum load to zero. Since S_1 can be calculated, the necessary clearance can be found and the mechanism designed to suit. Taking a particular case, suppose a pump is required suitable for a four-cycle engine developing 100 b.h.p. per cylinder at 200 r.p.m. Assuming a total delivery for the pump of double the quantity of oil required. We know from experience that the maximum fuel consumption will be about ·42 lb. per b.h.p. per hour, so that the maximum delivery required will be 42 lb. of fuel per hour. (The consumption per hour is taken since the quantity of oil delivered per stroke is very small, hence appreciable errors might occur in the calculations). If we make the pump plunger $\frac{3}{4}$ in. in diameter, with a stroke of 1 in., the total delivery will be

$$0.4418 \times 1 \times 100 \times 60 = 2650.8 \text{ cub. in. per hour}$$

or $2650 \cdot 8 \times \cdot 033 = 87\frac{1}{2}$ lb. per hour, of fuel, which is just about double the quantity required. Assuming that for mechanical reasons the bottom link k, (Fig. 3) is designed so that the ratio between x and y is 4 to 1, then the stroke s of the tappet will be $\frac{1}{4}$ in.

Now, since the delivery of the pump is proportional to the length of the stroke

$$\frac{S_1}{S} = \frac{D_1}{D} \qquad (2)$$

But for the maximum load

$$D_1 = 42 \text{ lb.}$$

and the total delivery

$$D = 87\tfrac{1}{2} \text{ lb.}$$

and

$$S = 1 \text{ in.}$$

$$\therefore \quad S_1 = \frac{42}{87.5} \times 1 = 0.48 \text{ in.}$$

Now, by equation (1),

$$\text{the clearance } c = \frac{S_1 \times s}{S}$$

$$= \frac{0.48 \times 0.25}{1} = 0.12 \text{ in.}$$

Therefore, the governor must transmit a motion to the tappet of ·12 in. to satisfy the conditions necessary for full load to no load. To allow for overload and to ensure the valves being quite free of their seats at no load, and to allow for any loss in the volumetric efficiency of the pump, the maximum motion of the tappet would be made slightly greater, say, ·15 in.

Another type of pump found on some stationary engines has the tappet driven by a separate eccentric, set at an angle to the plunger eccentric, which necessitates a different procedure in the calculations; however, as the design is practically never met with in marine engines, the details need not be entered into here.

Constructional Details.—It will be seen from the foregoing remarks how sensitive the regulating mechanism of the Diesel engine must be to ensure rapid adjustments in speed, and the necessity for eliminating any tendency to backlash in the link mechanism. All pin joints should be of ample size, the pins case-hardened and ground, working in hard steel bushes accurately ground to size. All links and levers must be rigid enough to avoid any tendency to spring. The suction valve stem and the tappet rod should be case hardened, with a good area of contact.

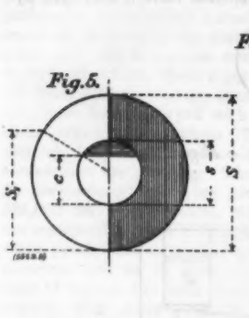
The body of the pump is usually of cast-iron, except for small sizes when brass is used. Close grained cast-iron of the best quality must be used and great care taken in casting to avoid blowholes or spongy metal, as the valve seats must be perfect.

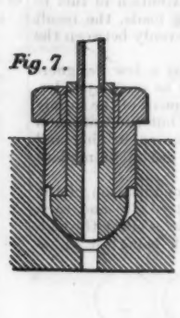
The plunger is usually made of high-grade steel, sometimes of mild steel casehardened. If the plunger is too soft, it will wear very appreciably where it passes through the gland, when trouble will be caused by leaky glands. The plunger is secured by suitable means to a crosshead guide, driven by the eccentric, the cross-head having attached to it a rigid arm for driving the tappet rod through the links. The plunger rod must be stiff enough to resist bending, and can be treated as a long column, when it can be checked by Euler's formula.

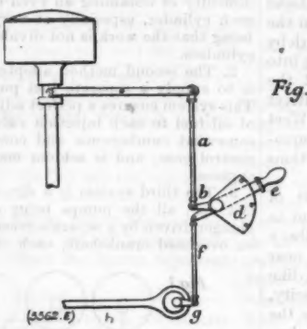
Plenty of clearance should be allowed between the top of the pump and the cross-head to allow the gland nut to be lifted sufficiently to repack the plunger gland without taking the pump to pieces, a point not always observed.

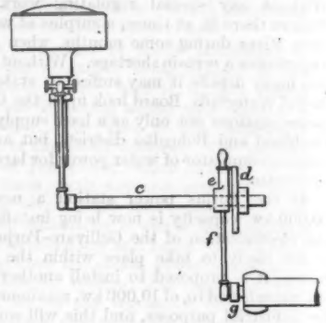
The suction valve should be case-hardened or made of high-grade steel, and is usually of the mushroom type, the delivery valve being of the thimble type, usually of nickel steel. In some cases two delivery valves are fitted in tandem, since, if there is only one, and it should leak badly, the blast air pressure would blow back into the pump and put an unnecessary pressure on the suction valve during the suction stroke, straining the regulating mechanism, and blowing air past the suction valve into the oil chamber, hence blowing the oil out of the pipes, and stopping the engine. If only one delivery valve is fitted, a non-return valve should be fitted on the fuel delivery pipe at the injection valve. The valves should be located in the most convenient position, well clear of the plunger, to allow them to be ground-in in place.

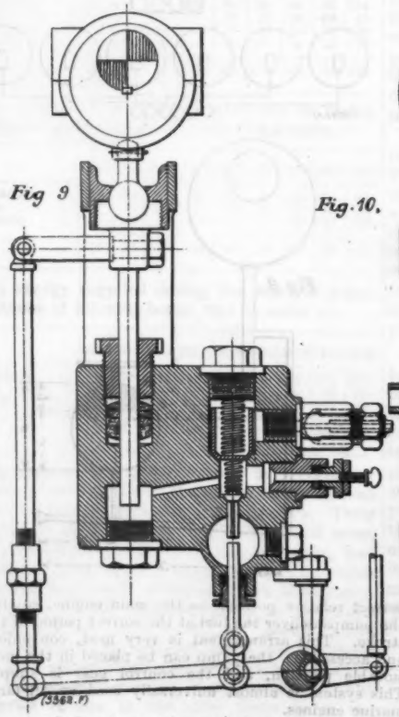
A small hand plunger is usually fitted to enable the piping and injection valve to be primed up before starting, as shown in Fig. 6. It is also useful for testing

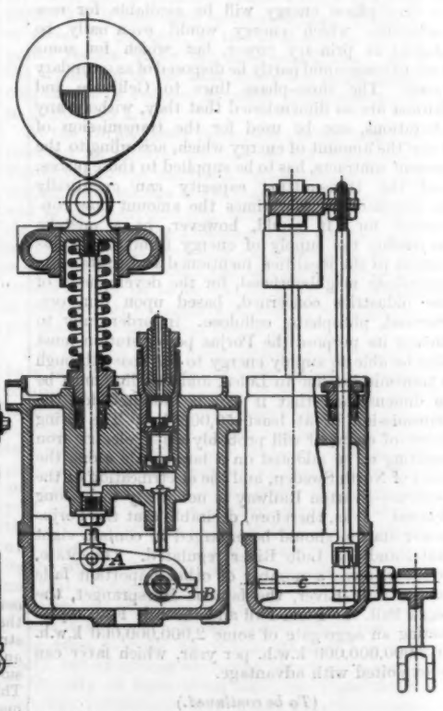












the valves before running the engine to see that they are in working order.

A small vent-cock should be fitted over the delivery valve to get rid of any air, and also to test whether the pump is working or not.

The fuel pipes are usually made of steel, as it is not attacked by the fuel as readily as copper. All connections should be of the cone type, as shown in Fig. 7. There is usually a small strainer of very fine mesh connected to the pump on the main fuel pipe, but this is only additional to the usual working strainers. Efficient straining of the fuel is most important, owing to the necessity of keeping the valve seats in perfect condition.

Control lever.—As it is necessary to stop the engine by a hand control gear, and also to regulate it by the governor gear, a similar device to the following can be used. The governor link *a*, Fig. 8, is connected to a bell crank *b* on an intermediate shaft *c* and to this is rigidly connected a quadrant *d*. The hand lever *e* rotates about the shaft *c* but engages with the quadrant in the usual manner, and is also connected to the bell crank *g* which is attached to the pump control shaft, by the link *e*. When in running position, the governor transmits its motion to the quadrant, and through the quadrant to the hand lever and the pump. To stop the engine, the handle is disengaged from the quadrant and rotating on the shaft *c* lifts the bell crank *g* independently thus raising the suction valves from their seats and stopping the engine.

By referring to Fig. 9, which shows a cross-section through a typical fuel pump, it will be seen that a right and left-hand nut is provided on the driving link for the regulating gear, by means of which the clearance between the tappet and suction valve can be adjusted.

Fig. 10 shows a cross-section through a pump, which is a variation from the usual design. The plunger is driven by a cam instead of an eccentric, the return motion being obtained by a heavy spring. The delivery valves are in duplicate. The driving link for the suction valves is brought to the side of the pump and attached to the arm A. The other end of this arm rests on a bell crank B, which is connected to the horizontal shaft C, which is again connected to the hand-control lever and governor. By rotating the shaft C, the bell crank B lifts the arm A, thus altering the clearance between it and the suction valve. The arm A acts as the tappet in this case.

All designers embody their own ideas when designing fuel pumps, but the general principles explained in this article will usually be found in the great majority of pumps, the only difference being in appearance and arrangement of details.

CONSTRUCTION AND TRIALS OF 30,000-TONS BLACK SEA FLOATING DOCK.

The floating dock of 30,000 tons capacity built by the Russian Shipbuilding Company at Nicolaieff was the second dock built for the Black Sea to the designs of Messrs. Clark and Standfield, of Victoria-street, Westminster, with whom were associated Messrs. Swan, Hunter and Wigham Richardson, Limited, who acted as technical advisers in the actual building of the dock and supplied some of the machinery. The first dock, about 6,000 tons capacity, was built in 1875-78, under the personal supervision of Mr. Lyonel Clark, and is still in good working condition. The present dock was ordered by the Russian Admiralty on April 1, 1913, and was to be delivered on July 1, 1915. The principal dimensions, as will be seen from the engravings on page 558, are, including the end platforms, about 656 ft. overall; width measured on the deck between the side walls, 137 ft.; full width, 167 ft., and the height of the side walls from deck to the top, exclusive of the deck houses on the top of the wall, 45 ft. The dock comprises five pontoons, of which the three central ones are 130 ft. long, 167 ft. wide, and 20 ft. deep; the two end pontoons, of the same width and depth, are only 80 ft. in length, but they are prolonged by end platforms, one on either end of the dock, making them the same length as the central pontoons. These platforms are 136 ft. wide where they take on to the pontoon and 30 ft. at the extremities, their length being 49 ft.

All the pontoons are of similar construction. In the centre there is the main watertight longitudinal bulkhead, heavily stiffened, with breathing plates, spaced 2 ft. 6 in. apart. On each side of the central bulkhead of a distance of 46 ft. is another longitudinal watertight bulkhead, and two more bulkheads in line with the face of the walls divide the pontoons into six transverse divisions. The space between the wall and intermediate bulkheads forms a sealed air space of sufficient dimensions to balance about 80 per cent. of the weight of the submerged dock. Longitudinally, the pontoons have one transverse watertight bulkhead each, which divides the central pontoons into two compartments of 60 ft. and 70 ft. long; the division of the end pontoons constitutes also two compartments each 40 ft. long. Every 10 ft. there is an ordinary non-watertight transverse bulkhead or girder, and the longitudinal intercostal frames between them are spaced 2 ft. 6 in. in the watertight compartments and 2 ft. in the air chamber. Thus each pontoon has eight watertight compartments and four air chambers. The walls which run the whole length of the pontoons are seated directly on the top of these, to which they are securely bolted, by means of heavy angle-iron rings, running all round their base, the outside of the pontoon being provided with a similar ring. The division of the side walls comprises four watertight bulkheads, which divide the walls into five compartments, corresponding to the length of pontoons. The internal structure of the wall consists of transverse frames, spaced 2 ft. 6 in., like the intercostal frames in the pontoons.

The pontoons were erected separately, contrary to the usual custom which is to build and launch these docks as a whole, but there were reasons which made the Russian Shipbuilding Company adopt this scheme.

To begin with, the erection of separate pontoons did not require specially prepared berths. The ground alongside the River Ingul was simply graded to the necessary declivity, and the bottom plating was erected on blocks. No piledriving was done except

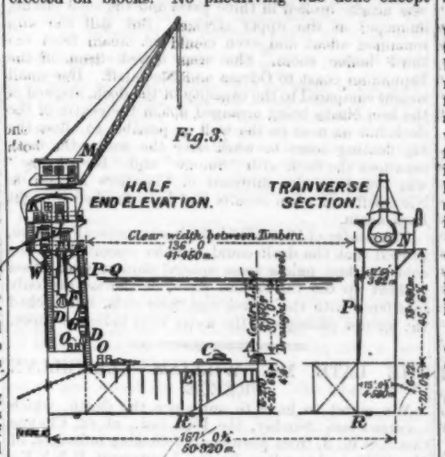


Fig. 3.

that required to extend the quay to the length occupied by the three central pontoons, and under the launching ways to take the pressure of the bow cradle. That arrangement saved much money which would otherwise have had to be spent in preparation of the berth for the whole dock, and also a considerable saving was made in launching arrangements.

Another reason was that it would have been impossible to obtain sufficient quantities of material, which arrived intermittently, and very irregularly; the last instalment arrived at the shipyard after a delay of nearly one year in excess of the contract time. The third and probably the principal reason lay in the arrangements for payment made with the Russian Admiralty, whereby interim payments were made after the erection of such and such a quantity of steel for each pontoon separately, and for launching each pontoon separately as well.

The angle bars and small plates were cut and punched, and the intercostal frames were assembled and riveted, in the main shipbuilding shop and its yard, which were situated about 70 ft. above the water level. The finished lot was sent down either by rail or by the aerial ropeway. The hull plating, deck, bottom and bulkhead plates were punched out and planed, where required, at the lower yard close to the site of erection. There were several steam cranes with specially long jibs, and for the erection a ropeway over the pontoons had been built and fitted with pneumatic winches. This arrangement was shifted along the pontoon as one of its section was completely erected. Those pneumatic winches of the de Bergue type, proved to be very handy and effective.

All punching of plates was done by a multiple punching press built by Phœnix and Co., of Petrograd. The press itself was very like those of the ordinary type, but it was fitted with a special device to control the punches automatically. This device was constructed to the design of the assistant manager of the ship-building department, Mr. Alexis Zvorykin, A.M.Inst.N.A. The device was very effective, helping the man in charge of the multiple punching press, and reducing the number of erroneously punched plates to a very insignificant amount. For launching the pontoons two launching ways were laid with a gradient of ¾ in. per foot; they were straight without any camber. Their foundations were extended with wooden baulks and lugs to take the initial cradle-pressure and where that pressure was calculated to be too great to be borne by the simple widening of the foundation of the ways, piles were driven to take the gradually increasing cradle-pressure. The end of the standing ways was about 1 ft. above the level of the water, so the pontoon had to drop when leaving the ways. The length of the standing ways was just sufficient to avoid the tilting of the pontoon over their end before it was waterborne.

The launching of the pontoons was effected very successfully, and created a splash about 20 ft. high, as the pontoons left the ways and covered the drop of 1 ft. Triggers were used for launching operations.

The erection of the side-walls, which would have been a complicated and difficult job, if carried out when the pontoons were on their berths, was effected much more easily when the pontoons were afloat, for the bottom of the walls was closed in by a watertight deck, which, forming as it did the bottom flange of the walls considered as girders, had to be of considerable thickness, and was riveted from the underside to the frames and joint angles.

This was carried out in the following manner: The deck with its frames and angles was erected on top of the pontoons on 3-ft. trestles, together with the first strake of side plating.

When all the necessary riveting had been finished, the operation of lowering the channel-shaped girder, the upper edge of which had been stiffened with angle bars temporarily bolted, to reduce the stress on the metal, was performed in this way. The first, third and fifth pontoons were flooded just to allow the trestles and blocks to be released; then the similar operation was done on pontoons Nos. 2 and 4; then continued flooding of pontoons Nos. 1, 3, 5 combined with pumping out of the pontoons Nos. 2 and 4, brought the latter into proper contact with the side walls; the strong joint-bolts were used to bring the pontoons into their proper place exactly.

The remaining erection of the side walls was effected with the assistance of the floating crane, which put in position the frames and outside plating. The long-jibbed locomotive cranes, along each wall, assisted in the erection of the inside plating.

The erection and fitting out was considerably delayed owing to the war, and to the necessity of concentrating all the efforts on the battleship "Imperatritza Maria," and to the fact that delivery of some of the auxiliaries was entirely stopped. The main-power generators ordered from the A.E.G. in Berlin had just passed their shop-tests when the war broke out. At the end of April, 1916, the dock was towed down to the place, where its temporary mooring had been prepared. At that time the equipment of the dock consisted of 10 centrifugal pumps with their motors. There were four of 55 h.p. for the pumps in the end pontoons and six of 75 h.p. for the middle pontoons. Electric energy for driving those pumps only was generated in two (one on each wall) dynamos, while the energy for auxiliaries, such as lighting, travelling cranes, and fire-pumps was supplied by the special lower voltage dynamos, also one one each side; a cross-connection cable from one wall to the other allowed any pump to be driven from either turbo-dynamo. One auxiliary motor-driven dynamo was fitted for lighting purpose only. There were also two air compressors and six steam capstans. Condensers with their circulating pumps had not arrived yet and the distilling plants had not been fitted. The water-level indicators, though not finished, were in a reliable condition, but the electro-pneumatic system for valve operating was not finished and consequently, the hand-operated gear had to be used. No telephones had been installed.

In that condition dock had to pass its preliminary trials when empty, and also to lift the old battleship "Sinope," which was to be docked to have her anti-torpedo belt fitted around her hull. It was a belt of two-chamber tanks running three-quarters of her length; the first, outside compartment, was filled with air and the inner, close to the hull, with water. The purpose of that was to allow the first blow of the torpedo to be spent on the air chamber, after which the intermediate bulkhead between the water and air chambers would take the blow, and not until both of them were destroyed could the impulse of the explosion reach the hull of the ship. This belt had the effect of reducing the speed from 12 to 5 knots, but its efficiency as a protection against explosion has never been tested.

Though the dock was not completed at the time of the trials, the lifting of "Sinope" and lowering her again, with the subsequent lifting of the torpedo-boat destroyer "Bespokoyny," badly damaged by two mine explosions, was performed very successfully. The main difficulty during those operations was to avoid the list of the dock. As the calculated weight of the dock was about 18,000 tons, while her actual weight in the condition the trials were started was only about

13,000 tons, the difference about 5,000 tons made the sealed or air chambers disproportionately large in consequence, but the difference of level of water inside and outside the walls was very small. The difference between the estimated and actual weight of the dock was due to the fact that much of the machinery had not been fitted, and also that all the plating of the dock had been rolled to the lower limit of thickness. It would have been very simple to reduce the volume of the air chambers to the proper capacity, about 20 per cent. of the weight, by filling the chambers with water to the calculated level, but the Russian Admiralty insisted on the trials being made with the air chambers as they were.

As pumping was to be carried on only in the pontoons, whilst the water from the side walls ran out by gravity, the side walls were fitted only with flap-valves, allowing the water to flow freely into the walls, but being shut by the pressure of water when the direction of flow was changed. In addition to these flap-valves screw-down valves were fitted on the same pipe at the level of the bottom of the side walls. The flap-valves were to be operated by the electro-pneumatic system or by hand gear in case of emergency; the screw-down valves were to be operated by hand only. When the dock took a very insignificant list to either side the level of water inside the wall immediately became higher than that in the river, and the water began to flow out freely from the wall, still increasing the list until it reached a certain degree, sometimes very considerable. To reduce this inconvenience and to stop quickly the list the screw-down valves had to be slightly opened, and one man was kept for each pontoon on the top deck of either wall.

There was no difficulty in pumping out the pontoons, as the pumps and their motors had a good margin of capacity, and the piping system was designed to allow the whole pontoon being pumped out, or the pumping to be done from any combination of compartments. In the event of any pump being out of action the whole of the pontoon could still be emptied, by the pump on the opposite wall through a cross-connection pipe. In this case the valves had, however, to be regulated to even up the flow. That arrangement was used to flood the pontoons when lowering the "Sinope," because a tug-boat broke the chain of the flap-valve on the pontoon No. 3, thus stopping the flooding of that side. The damage was not discovered immediately, as the compartment valve indicators were not affected. Only when the sinking of the dock began to get slower and the list to increase did search discover the damage.

To avoid the inconvenience caused by the small difference between the levels outside and inside the walls, these could be connected, by removing the manhole covers in the bottom deck of the wall to the wing watertight compartments of the pontoons. Then the screw-down valves being closed the level inside the walls could be kept at any height wanted by suitably operating the valves in the pontoons.

There were no difficulties with the remaining part of the machinery. But one of the motors of the electrically driven fire-pumps attained a very high temperature. Having been overhauled and all the clearances corrected, the temperature was less but still much higher than allowable. The cause of it was that the number of blades in the fan was only one half of that needed and of that on another similar machine.

The second more serious trouble was with the condenser circulating pumps and their engines and shafts. The two-cylinder horizontal engines had their cylinders on both sides of the shaft, one about eight inches higher than the other just to give room for crank-pin and roller. The result was a considerable vibration of the deck, but this was met with an extra stiffening of the deck and foundation.

In calculating the diameter of the shafts the phenomenon of resonance had not been allowed for and several times either the couplings or their bolts were broken. Careful calculation showed that the diameter of the shaft happened to be exactly critical with reference to the resonance phenomenon. Just for experiment one shaft was renewed of a larger diameter, while the second shaft was reduced in diameter. The failure of couplings ceased, proving the correctness of the diagnosis.

As the Russian Admiralty failed to provide a 30,000 ton ship for the trials they were performed with a ship of only 10,000 tons, which was much shorter than the full extension of the keel blocks. A special scheme of pumping was worked out to avoid the longitudinal bending of the dock, which necessarily would occur if all the pontoons had been pumped out evenly without compensating for the absence of load. Thus the end pontoons and the end compartments of the second next to them were pumped out very little, or almost not at all, as no load was placed upon them.

To obtain the proper distribution of load across the pontoons the side keel blocks were made a little lower than the central ones to absorb the cross-bending which was due to the load from the ship and the buoyancy of the water. The distribution of the load was thus rendered as near to that calculated as possible. To obtain the better fit between the keel blocks and the bottom of the ship the keel blocks were capped with 1 in. of soft wood, which also allowed for small mistakes in the height of the blocks.

The second docking was that of the torpedo-boat destroyer "Bespokoiny," badly damaged by two mine explosions. This was not in any sense a test, since the dock was designed for 40,000 tons and the torpedo craft was only of 1,100 tons. (The nominal capacity of 30,000 tons was obtained with 1 ft. 6 in. water inside and 2 ft. free board. By pumping the pontoon out dry and reducing the free board to nil and adding the difference of about 5,000 tons between the calculated and the actual weight of the dock, its capacity would be about 40,000 tons.)

The damage done to the "Bespokoiny" was caused by one mine exploding right under the second boiler room, making a hole about 7 ft. in diameter, breaking through the keel, and by a second mine exploding under the port side engine-room, smashing the casing of the astern turbine. With those two holes the ship was nearly broken in three parts and the shell plating damaged in the upper strakes. But still the ship remained afloat and even could get steam from the third boiler room. She was towed from off the Rumanian coast to Odessa and Nicolaieff. Her small weight compared to the capacity of the dock, allowed of the keel blocks being arranged not in the centre of the dock but as near to the wall as possible to allow the big floating crane to work over the wall. On both occasions the dock with "Sinope" and "Bespokoiny" was towed to the shipyard of Chantiers Navale de Nicolaieff and when repairs had been finished brought back again.

The winter of 1916-1917, which was unusually severe, proved that the dock could not be operated in the cold weather, unless some special devices were fitted to heat up the valves and pipes, as the ice not only interfered with the valves and their rods, but choked the narrow passages of the water level indicator pipes.

THE LATE MR. WILLIAM LLEWELLYN PREECE.

We regret to have to announce the death, which occurred last Sunday, the 10th inst., at 42, Cheyne Court, S.W. 3, from pneumonia following influenza, of Mr. William Llewellyn Preece, Lieutenant R.N.V.R., M.Inst.C.E., M.Inst.E.E.

Mr. Preece was the eldest son of the late Sir W. H. Preece, and was born at Southampton on March 4, 1866. He was educated privately and at King's College School; he then, in 1883 and 1884 travelled on the Continent for the purpose of learning the French and German languages. In 1885, he studied at the Electrical College, Hanover-square, and obtained the certificate of the college at the end of the year. He then, in 1886, joined the staff of the Midland Railway, Telegraph Department, Engineering Branch, under the late Mr. W. E. Langden, and was appointed Inspector of the Central District in September of the same year, with charge of the electric lighting. On January 1, 1892, Mr. Preece was appointed Electrical Inspector of the Southern Division of the same railway.

Towards the end of the year 1898, Mr. Preece resigned his position at the Midland Railway, to join Sir William Preece, Major Cardew and his brother, Mr. A. H. Preece, and thus became a partner in the firm of Preece and Cardew, consulting engineers. Subsequently, in 1909, Sir John Snell joined the firm and, in 1915, Mr. John H. Rider, the firm becoming Preece, Cardew, Snell and Rider, 8, Queen Anne's Gate. Mr. W. L. Preece devoted most of his time as a member of the firm to telegraph, telephone and wireless telegraph matters. This included telegraph and telephone and wireless telegraphy work in all the principal Colonies, both under the Crown Agents and the High Commissioners for South Africa and New Zealand. He was responsible for various wireless telegraph stations, chiefly for the Colonial Office, at Aden, Fiji, Ceylon, Solomon Islands and, conjointly with Captain Brunot of the French Government, for the New Hebrides.

In 1912, Mr. Preece undertook a special investigation for the Federated Malay States Government of the telephone and telegraphs system in that Colony. He also visited Trinidad and other Colonies to report on similar questions. He gave evidence for the Post Office before the Parliamentary Committee upon the Marconi contracts.

In 1917, he received a commission in the Navy as lieutenant in the R.N.V.R., and his principal work has since been in connection with scientific devices for detecting the presence of submarines.

Mr. Preece read a paper in 1915 before the Institution of Electrical Engineers upon "Telephone Troubles in the Tropics." In 1914, he entirely revised the well-known text book on "Telegraphy" written by Sir William H. Preece and Sir J. Sivewright. He had recently been engaged in preparing a biography of his father, the late Sir William H. Preece.

Mr. Preece was elected an associate member of the Institution of Civil Engineers in 1897 and a full member in 1907. He was also elected an associate member of the Institution of Electrical Engineers in 1887 and a full member in 1897. He was a member of the council of the latter Institution up to the time of his death. He was also a member of many other scientific institutions.

In addition to his electrical engineering work, Mr. Preece was keenly interested in Church matters, and wrote many papers on religious subjects; he acted as secretary of a branch of the Churchman's Union. For some years he had been in indifferent health, and there is little doubt his work at the Admiralty and at Queen Anne's Gate imposed a strain which was beyond his strength.

"COAL SAVING BY SCIENTIFIC CONTROL OF BOILER PLANTS."

To the Editor of Engineering.

Sir,—There cannot be anyone more surprised than myself on the reply of Mr. Casmey in relation to my remarks as regards Lancashire boilers, and also about stokers. I have before me a bulletin regarding a boiler called the Yorkshire boiler, of which I see Mr. Casmey is the patentee. There are 28 pages in this work absolutely condemning the Lancashire boiler in every form. Then, again, we see in the letters that the Lancashire boiler should have been built the other way round.

Then, according to his letter of November 1, he has examined about 30 Lancashire boilers in the past month giving an average efficiency of 60 per cent., 16 of which gave 46 per cent. and some only 40 per cent.

Now then, Sir, this is what I call a test; don't have everything all arranged for a special spurt so as to show an efficiency for a few hours of some fanciful figure, but continue the test throughout the time the boiler is in use between successive cleanings.

Lancashire boilers have been good servants, but with our tendency towards higher pressures, and the knowledge we are gaining regards losses through settings and expansions of this brickwork, together with many other things, the Lancashire boiler has had its day for scientific use. I might add that I have no vested interest in anything relating to boiler or other plant, so that my conclusions are unbiassed.

As regards my remarks about stokers, I endorse what Mr. Casmey finds about these men in practice. I suggest he has not read my remarks carefully, otherwise he could scarcely have written in the style he has done.

I remain, Sir, yours faithfully,

J. H. Anderson.

Purfleet, November 9, 1918.

GALILEO.

To the Editor of Engineering.

Sir,—Though it seems that our world has dwindled down to a bare working maximum for everyday use, yet some masterly written articles of Engineering keep an interest alive on all engineering topics, and serve well the purpose of stimulating even those who are overworked.

In the skilful leading article for October 11, on "The Mechanical Properties of Materials," we read: ". . . The familiarity of these latter names in comparison with the general ignorance of the above-mentioned experimental work of Galileo, Fontenelle and Mushenbroeck, illustrates anew by how much a contribution to scientific thought outweighs even pioneering additions to scientific data." Turning to page 393 of the same issue, we read, in a well-deserving article by Sir G. Greenhill: "Galileo replaced this artless theory of ancient artillery science by an appeal to the ideal conditions of rational mechanics. *Ignoring air resistance*, he proved that the track of a shot in the air would be a parabola . . ." Quite true, but it must be understood that Galileo did not know all essential features of air resistance, and in the Dialogues on the Two New Sciences (*i.e.*, on cohesion and resistance to fracture, and on the uniform, accelerated and projectile motion) he writes*: "A heavy body has by nature an intrinsic principle of moving towards the common centre of heavy things—'the centre of the earth'—with a motion continually and equally accelerated, that is, in equal times there are always equal additions of velocity. This is to be understood when all external impediments be removed, amongst which is one that we cannot obviate, namely, the resistance of the medium . . . this opposes itself more or less according as it must open slowly, or speedily, to make way for the moving body, which being continually accelerated, encounters a continually increasing resistance in the medium . . . until at last the velocity reaches that degree and the resistance that power that *balances each other* . . . and the movable is reduced to have a uniform equal motion." To illustrate these ideas, he gives some figures and his talking on motion and matter is so clear and straightforward that even the powerful genius of Maxwell was

* "Le Opere di Galileo Galilei." Edizione Nazionale, vol. viii., 1918. Pages 118 and 119.

not always successful in beating Galileo's exposition when, 250 years later, he composed his celebrated booklet on "Matter and Motion."

What a pity that Shuster and Shipley should have written:* "Kepler passed away and Galileo died an old and broken man before one was born who surpassed both in genius and power as much as they had excelled those who went before them." Newton's science also was not free from drawbacks; but new contributions to scientific thought must not outweigh pioneering additions to scientific data.

The publication of the works of Galileo by the Italian Government has succeeded in throwing new light on the deeds of this giant of the past, and it is now clear that Galileo may surely be considered as the founder of dynamics as well as the greatest propounder of experimental physics. He may have died a broken man; but *his work* stands sounder than bronze.

I beg, Dear Sir, to remain,

OTTORINO POMINI.

Milano, October 30, 1918.

"THE TECHNICS OF MAGNETO-MAGNETS."

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of October 4, on page 361, there was published an article bearing the above title, on which I should like to make some comments, as the article deals with a subject upon which very little has been written, although it is of considerable importance.

Prior to the war very little consideration had been given in this country to the technical side of magnet manufacture, the work having been nearly all done abroad. During the past four years the subject has been taken up vigorously, and Professor Crapper's article is especially welcome as it affords the first good summary of the position of our knowledge of this work. In reading through the article, however, there are several points which are somewhat open for debate, and I would like to take the opportunity of calling attention to them, not in a spirit of adverse criticism of the article in question, but simply in the hope that Professor Crapper may be induced to elucidate somewhat further.

In the first place a statement is made that the theory of the high-tension magneto shows that the energy of the spark is proportional to the square of the maximum value of the magnetic flux traversing the armature core on open circuit. The theory of the high-tension magneto is too complicated and too large a subject to go into in the form of a letter to a technical journal, but I would like to point out that this statement is generally incorrect, or, at all events, is only true in very special circumstances, and that other factors, in particular the stiffness of the field, in addition to its magnitude, enter very largely into the question of the output of the machine.

In the third column on page 361 a statement is made that "the increase of flux density with increasing magnetising force is proportional . . ." This, surely, is incorrectly worded, as the statement "increase of flux density with increasing magnetising force" suggests the idea of the rate of increase of B with respect to H, *i.e.*, $\frac{d\,B}{d\,H}$. Apparently what is meant is not $\frac{d\,B}{d\,H}$ but the actual ratio of B to H.

The representation of the B–H curve by means of a straight line is very interesting, and probably may be of considerable utility to enable the B–H curve to be expressed by means of definite constants which could be tabulated and recorded for any particular brand of steel or heat treatment. Apparently, however, the linear equation given in the article does not hold for small values of B and H, as magnet steels show a very well-marked point of inflection in the curve in the neighbourhood of B = 1,000 and H = 50, and the point of inflection appears to be more marked, the better the quality of the steel.

If the value of the reluctance of a hardened tungsten steel is plotted against the values of H for the magnetising curve, the resultant reluctance figures have a high value for very small values of H, rapidly decreasing and finally turning into a straight line following the equation given by Professor Crapper. The linear equation does not, however, hold below the values of H = 100, corresponding approximately to the point of inflection on the B–H curve.

The curve of demagnetisation can be expressed very closely indeed by a linear equation similar to the one given by Professor Crapper, the equation in this case being $\frac{H_c + H}{B} = a + b\,(H_c + H)$, and this straight line appears to be very nearly parallel to the one which expresses the magnetisation curve. The constants of the equation are probably of value inasmuch as they give a representation of the demagnetising loop which is the most important portion of the B–H curve of a magneto magnet.

Professor Crapper has not stated in the article how the values of B_{max} in the second column of Table II are arrived at. These are certainly not the saturation values obtained by taking the reciprocal of *b* in equation (3) on page 361. Apparently they are the values of flux density in the magnet when subjected to a magnetising force of H = 400, which for some reason has been adopted generally in the magnet industry, as being a suitable value for the magnetising force to be applied when magnetising and testing magnets. This is purely an arbitrary figure, and it would be interesting to know the reasons for adopting this as a standard. It is rather doubtful whether it is really high enough to ensure thorough magnetizing of a magnet when the steel is of a very good quality indeed, as with very high-class steels a higher remanence figure can be obtained when a greater magnetising force than H = 400 is applied.

Professor Crapper suggests the use of a constant termed the coefficient of retentivity, which appears to be the ratio of the remanence to the value of the flux density for H = 400, although this again is not stated in the article. He also mentions that the coefficient of retentivity for magnets of a *certain size* is of the order of 0·65. It is not clear why this qualification has been inserted, as the coefficient of retentivity should be independent of the size of the magnet provided the remanence reading is taken on a closed ring of steel on which there is no demagnetising force existing when the magnetising force is removed. Professor Crapper does not give details of the magnetic tester to which he refers, but in one type the flux reading is taken under different conditions from those prevailing with a closed ring of steel, and the flux readings given by this are not true values of B_{rem}, but are considerably lower than this and are therefore not truly indicative of the coefficient of retentivity as defined by him.

The rigidity numbers given in the sixth column of Table II appear to have been taken on an arbitrary standard in which specimen B has been taken as unity. I am not clear as to why this has been adopted and why the rigidity numbers should not have been given in actual units of H obtained by taking the intercept of the tangent on the H axis, and there seems to be no reason why they should not be expressed in these units.

Professor Crapper suggests the value of the apparent flux density B^1_{rem} with the demagnetising force of H = − 30 instead of the ordinary value of B_{rem}, and he also suggests the use of the ratio $\frac{B^1_{rem}}{B_{rem}}$ in place of this. He seems to be of the opinion that the value of the ratio is of more importance than the actual value of B^1_{rem}. I do not quite follow him in this argument as B^1_{rem} represents almost exactly the conditions under which a magneto operates, *i.e.*, it is the flux which the magnet is capable of giving in the magnetic circuit when it is subjected to certain demagnetising influences such as those of the armature of the magneto, or the reluctance of an air gap.

I take it that of two magnets, one having higher values of B^1_{rem} and B_{rem} than the other, but having the same ratio between these two quantities, the first of the magnets would give appreciably better results in service, although the ratio was the same in each case. It is a fact known to those who have had experience with different types of magnets, that it is possible to obtain two magnets having the same remanence and coercive force, but in which the B–H curves are of different shape. In such a case B^1_{rem} for one magnet would be higher than for the other and so also would the ratio $\frac{B^1_{rem}}{B_{rem}}$. The magnet with the higher value of B^1_{rem} and also of the ratio, will certainly give better results in service, but this cannot be taken as evidence of the importance of a high value of $\frac{B^1_{rem}}{B_{rem}}$ unless considered in conjunction with that of B_{rem} also.

Professor Crapper's reasoning with regard to the value of K^2 taken at the point of H = − 30 is not quite clear, and I think his statement in connection with this would be well if it were further amplified. Neither does it agree with practice, for instance, the two tungsten steel magnets given in Table II have a much higher value of K^2 than the two carbon steel ones, yet the statement is made "the more satisfactory the magnet, the smaller the value of K^2." This surely is not correct, as certainly tungsten steel magnets are much more satisfactory than carbon steel ones.

It is true that high permeability and relative large remanent intensity go together, and are generally associated with a low value of coercivity, but the statement that such a steel develops a large value of magneto-motive force for a particular unit volume is surely incorrect, as a high magneto-motive force implies a large coercivity, and not a low one.

I quite agree with Professor Crapper that the requisite and vital property, at all events, in magnets which are subjected to a large demagnetising force, and work under severe conditions, is a high coercivity, and that very large values of remanence, unless accompanied with a corresponding value of coercive force, are not of great importance.

After all the real requirements which have to be fulfilled by a magnet, are that it shall provide a certain number of lines of force when subjected to a definite demagnetising force equivalent in the case of a meter magnet to the magneto-motive force required to drive the working flux across the gap. Given this data it is quite easy by the construction given by the author in Fig. 4 to find the actual working flux which will be provided by a magnet of given dimensions and known magnetic properties. The case of a magneto magnet is not, however, quite so simple, as the magnet is not used in conjunction with a circuit of constant reluctance, but with one in which the reluctance is continually varying, and in which, moreover, there is at certain periods a definite opposing magneto-motive force, due to the currents in the armature coils.

In such a case we have to consider not only the extent to which the flux given by the magnet is cut down by the armature reluctance and reaction, but also the extent to which the magnet can recover in the intervals between the periods in which it is subjected to the armature reaction. Data on this point seem to be lacking. It appears to be true that the flux in a permanent magnet can be temporarily cancelled by a demagnetising force and yet becomes partially restored on removal of the force. Such restoration appears, however, to be small, especially when precautions are taken to guard against errors due to the presence of leakage fields. An interesting query in connection with this point is—What would be the percentage of the original remanent flux left in a horseshoe magnet if the keeper were removed and the magnet immersed in a totally impermeable medium, or in other words, if the flux given by a permanent magnet is completely annulled and not merely diverted, is the magnet capable of re-establishing it? I have never yet seen a satisfactory answer to this query, and perhaps Professor Crapper could throw some light upon it. Certainly the behaviour of different magnets under conditions somewhat analogous has a very direct bearing upon their suitability for use in a magneto.

I am, yours truly,

Coventry, October 24, 1918. E. D. WATSON.

* "Britain's Heritage of Science," Constable and Co., Limited, London. First impression, 1917; second impression, 1918. Page 8, lines 5 to 8.

WOMEN IN THE DRAWING OFFICE.

TO THE EDITOR OF ENGINEERING.

SIR,—May I reply to the very entertaining letter of Mr. Ernest H. Walker in your issue of the 8th inst. He credits me with a statement to the effect that "women are specially suitable for such semi-skilled operations as tracing and draughting." If I had really made myself responsible for such an inaccurate statement I should have richly deserved the satirical comments which Mr. Walker has given expression to. My only reference, however, to women engaged on drawing office work, on the occasion referred to, was the following:—

"Women have made excellent tracers, and in some cases can piece drawings together, but there are no draughtswomen at the present time, and there cannot be any unless the work is taken up by those who have at least three or four years shop experience, an indispensable element in the making of a draughtswoman."

In these circumstances Mr. Walker's excellent humour rather loses point.

As one who has employed a good number of draughtsmen, I have always felt that they are a much underrated class from the points of view of qualifications, status and remuneration. The war has "rediscovered" them, and I hope Mr. Walker's versatile parts will succeed in gaining for them a full and proper measure of appreciation *and pay*.

Yours faithfully,

BEN. H. MORGAN.

15, Dartmouth-street, S.W. 1,
November 12, 1918.

COAL-GAS FUEL FOR MOTOR VEHICLES.—The Automobile Association has received several entries for its competition for a 1,000*l.* prize offered for the best system for enabling coal gas to be satisfactorily used as a fuel for motor vehicles. In addition, a large number have signified their intention to compete for the prize, but have not yet definitely entered as competitors. The closing date for the competition is December 31, 1918. Those who have postponed their entries should communicate at once with the Secretary, Automobile Association, Fanum House, Whitcomb-street, London, W.C. 2.

CONSTRUCTION OF MAIZE ELEVATORS IN SOUTH AFRICA.—A Special Committee, under Sir William Hoy, general manager of the South African Railways, says *The Board of Trade Journal*, which gives full information on the subject, has presented a report recommending the construction of elevators at the ports and the various inland collecting stations for dealing with the maize and other cereal crops of South Africa. It is demonstrated in the report that under anticipated post-war conditions, and taking a conservative estimate of certain savings which can be definitely located, there should result from the elevator system—when it becomes fully established, and industry is adapted to the bulk system—a direct financial saving to South Africa of at least 500,000*l.* per annum, after paying interest, depreciation, repairs and cost of operation of the elevator system. In calculating the above savings, no charge has been made against the present system for interest, depreciation and repairs for railway, harbour, and private sheds and stores used for grain, whereas the elevator costs include those items. The above estimates do not include the following material advantages, which cannot accurately be expressed in figures: (1) Savings to railways and harbours through more rapid handling and movement of grain traffic; avoidance of congestion and of detention of trucks, &c. (2) Savings to railways and harbours through economy of space, less expense for harbour land, sheds, wharves, channels, &c., and through costly harbour extensions being avoided. (3) Pooling of maize for rail transport. (4) Advantage of negotiable certificates, which will facilitate trade and reduce cost of marketing. (5) Impetus to increased production resulting from improved storage and transport facilities, better returns received by the farmer and more stable market conditions. (6) Release of labour for productive work. (7) Elimination of disputes re weights and grades. For the 1917 crop year (July, 1917, to June, 1918 inclusive) the quantity of maize conveyed by rail exceeded that for the calendar year by about 1,000,000 bags, but the complete figures were not available. Much of the crop was destroyed by wet and exposure, and it was estimated that the export surplus originally available from the 1917 crop was about 5,000,000 bags, part of the balance of 1,000,000 bags having been destroyed and part diverted to local uses owing to difficulties of transportation. As the above figures do not include Kaffir corn and other classes of grain, the total quantity of all classes of grain which would have been available for transport by rail, but for the adverse climatic conditions, was estimated at 1,200,000 bags.

STANDARD CONCRETE BARGE; NEW YORK BARGE CANAL.

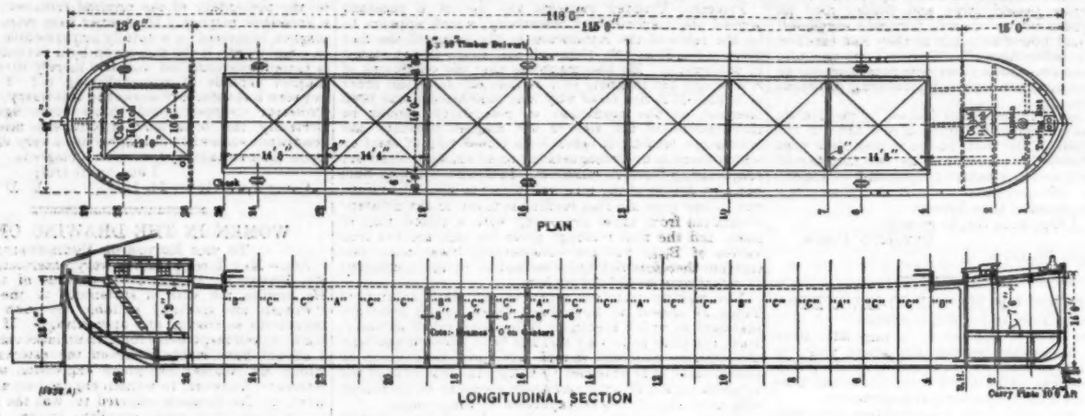


Fig. 1.—General Arrangement Concrete Barge. Length, 150 Feet; Beam, 21 Feet; Depth at Sides, 12 Feet

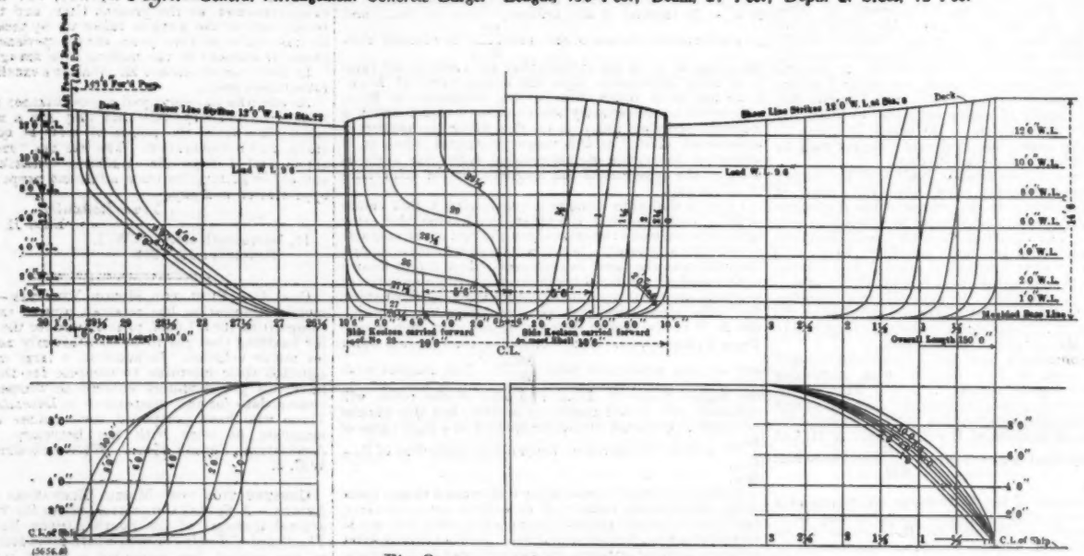


Fig. 2.—Lines of Concrete Canal Barge

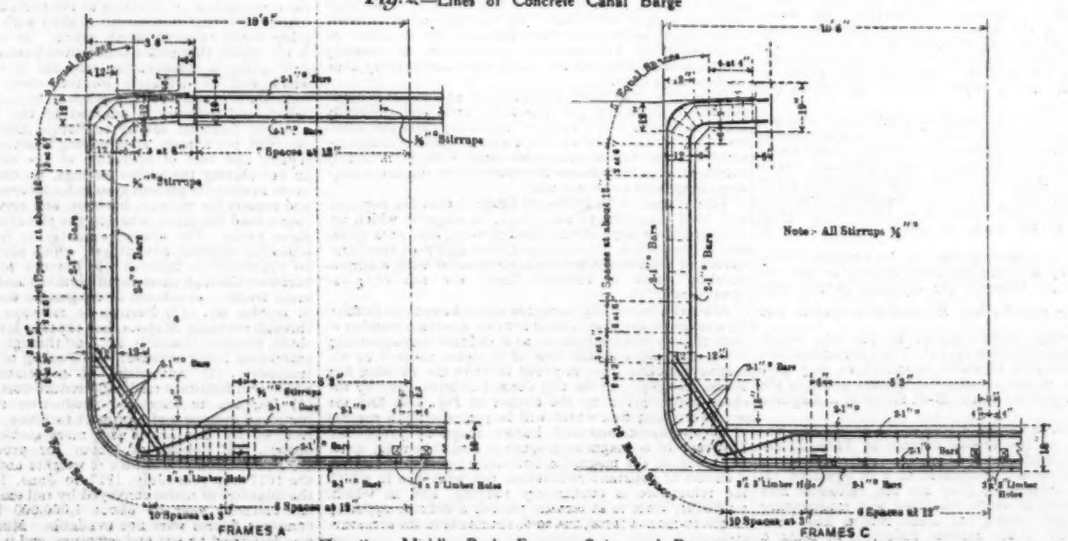


Fig. 3.—Middle Body Frames, Sides and Bottom

STANDARD CONCRETE BARGE FOR USE ON THE NEW YORK STATE BARGE CANAL*.

Pursuant to their policy of issuing completed plans to the shipbuilding industry, the Emergency Fleet Corporation has again come forward with drawings and specifications for the construction of a standard concrete canal barge for use on the New York State barge canal.

The boat is 150 ft. long, 21 ft. beam, and 12 ft. depth at the sides. It has a load draught of approximately 9½ ft., a displacement, loaded, of 756 tons, and a dead-weight carrying capacity of about 489 tons. It is of the open-hull type, with cargo hatches 13 ft. wide, leaving 3½ ft. deck space on each side.

For most of its length the hull is practically square, with a rounded bow and ship-shaped stern. The main frames along the bottom are 6-in. by 18-in. girders, with square bar reinforcement in upper and lower planes connected by small bar stirrups. At the sides the frames are 6-in. by 12-in. girders, turned at the deck and extended to the hatch coamings. Every fourth frame is carried across the hatches as a cross brace.

* Extract from *Marine Engineering*, New York, of October, 1918.

STANDARD CONCRETE BARGE; NEW YORK BARGE CANAL.

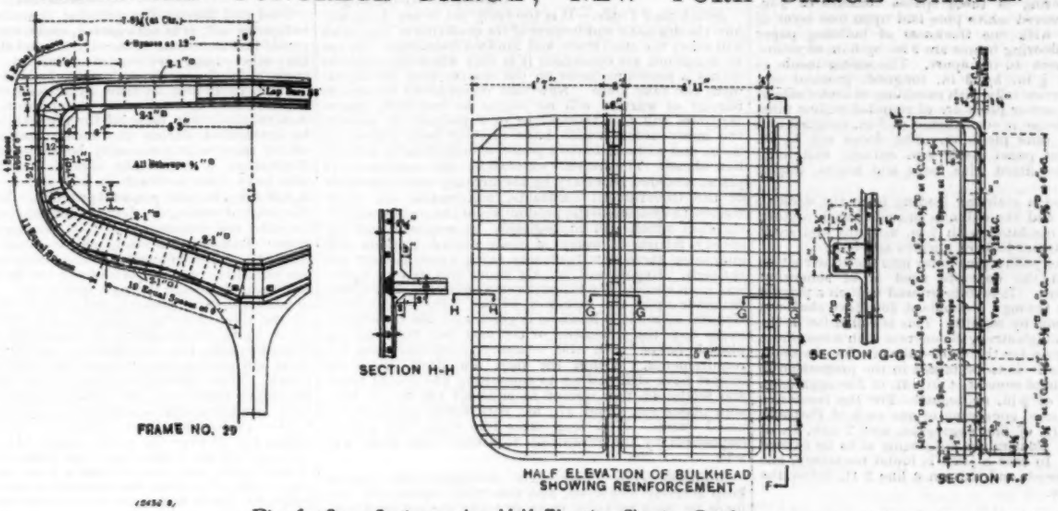


Fig. 4.—Some Sections and a Half Elevation Showing Reinforcement

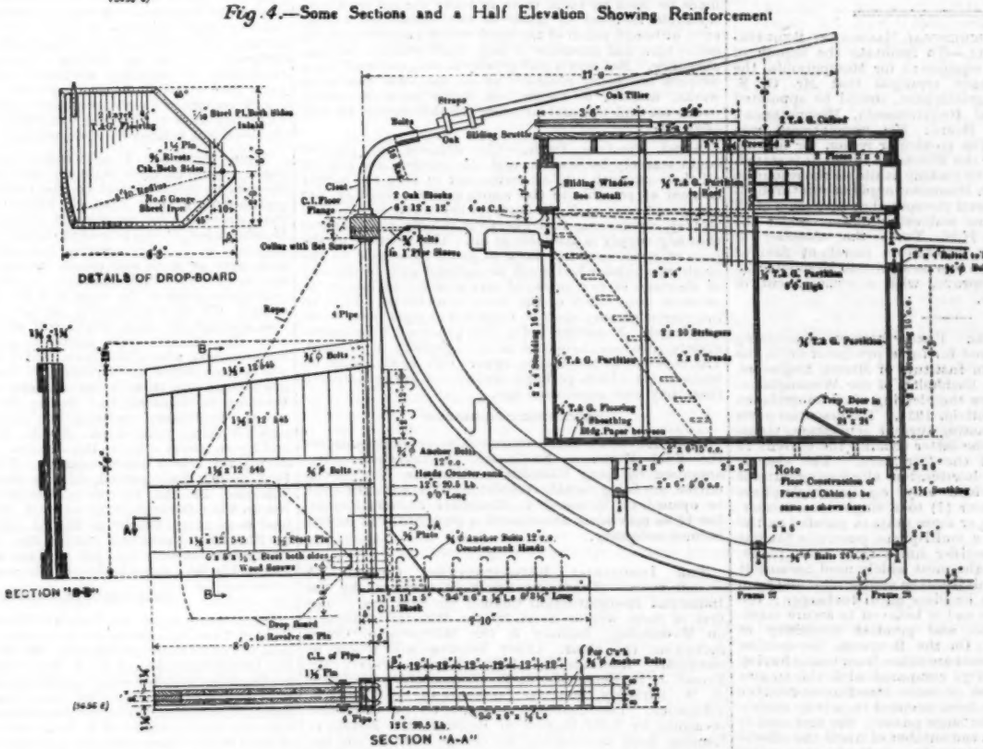


Fig. 5.—Details of Drop Board and Design of Rudder Posts

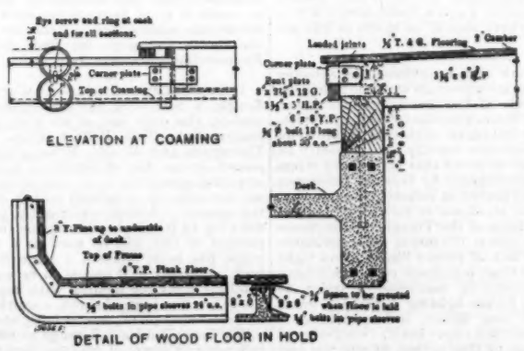


Fig. 6.—Details of Coaming and Wood Floor

The barge has a centre and two side keelsons forming the longitudinal stiffeners, and side frames of normal reinforced concrete girders, spaced 5 ft. on centres and carrying an outer single shell. Except forward of the forward bulkhead, where the shell is 4½ in. thick, and aft of frame 26, where it is 4 in. thick, the shell is 3 in. thick, as is also the deck slab. Both the shell and deck slabs are reinforced with ½-in. and ⅜-in. rods running horizontally and variously spaced, according to the location in the shell or deck. There are also ½-in. vertically running shear rods spaced 7 in. centre to centre. At the turn between the side and the deck, the shell is further stiffened by a number of longitudinal rods.

All horizontal steel in the sides on the midship section is carried around the bow and stern. The steel in the bottom and bilge is carried forward and aft as far as possible without interfering with the steel from the sides. A transverse bulkhead, consisting of a 3-in. vertical wall bearing against three 7-in. vertical girders which frame into longitudinal deck girders, is provided 15 ft. from the bow.

In the hold a wooden floor, consisting of 4-in. plank, is laid across the frames and extends up the sides to the under sides of the deck. The hatch covers are timber frames which can be lifted off the seat and are made up of 6-in. by 8-in. yellow pine timbers bolted to the rein-

forced concrete girder forming the hatch coaming. Cabin and storage spaces are provided in the bow and stern. The flooring in these spaces consists of ¾-in. tongued and grooved white pine laid upon one layer of ¾-in. sheathing with one thickness of building paper between. The flooring beams are 2 in. by 6 in. of yellow pine spaced about 16 in. apart. The siding inside is of yellow pine, ¾ in. by 3 in. tongued, grooved and bevelled, laid horizontally with moulding at under side of windows. The corner posts are of rounded yellow pine. The top of the house is constructed of 2-in. tongued and grooved yellow pine planking. The doors are 1¾ in. thick, framed, of panel inside and outside, and hung with brass hinges fitted with locks and knobs, staples and buffers.

There is a wooden stairway leading from the deck to the cabin door, and the cabin is provided with a stove stand, properly insulated with ¾-in. asbestos and sheet metal, and a sink and lockers, shelves and bins.

Spruce, oak and yellow pine enter into the construction throughout, and the concrete used is of somewhat unusual refinement. It is to be ground to such a powder that the residue through a standard 200 sieve shall not exceed 10 per cent. by weight. This is called for in the hope of getting a high strength concrete with a minimum of delay. Concrete for the slabs—that is, for the deck, bulkhead and shell—is to be mixed in the proportion of one sack of Portland cement, ½ cub. ft. of fine aggregate, and 1½ cub. ft. of ¾-in. aggregate. For the frames, a concrete can be used consisting of one sack of Portland cement, 1 cub. ft. of fine aggregate, and 2 cub. ft. of ¾-in. aggregate. Continuous concreting is to be carried out if possible. In case a joint is found necessary, one only will be allowed, and this on a line 2 ft. below the deck of the barge.

Controller of Agricultural Machinery Requirements in Mesopotamia.—To facilitate the supply of agricultural plant and equipment for Mesopotamia, the Indian Government have arranged that Mr. G. S. Henderson, Imperial Agriculturist, should be appointed Controller (Agricultural Requirements, Mesopotamia), under the Munitions Board. His appointment was gazetted on July 6. The particular reason for making this appointment under the Munitions Board, it is stated, is to facilitate the work by making available the resources controlled by the Indian Munitions organisation throughout India; and to this end the special co-operation of all Controllers of Munitions and other officers under the Board is requested. H.M. Trade Commissioner at Calcutta states that a well-known merchant firm at Calcutta intend sending a representative to Mesopotamia, if the Government approve, with a consignment of agricultural implements.

Electrostatic Fume Precipitation.—Discussing the electric plant required for fume precipitation in the Bulletin of the American Institute of Mining Engineers, of August, 1918, P. H. Eschholtz, of the Westinghouse Electric Company, traces the clearing of a smoke-laden atmosphere back to Hohlfeld, 1824. The essential parts of the plants are alternating-current generators, transformers and rectifiers, the latter sending the current to the axial electrodes of the "treaters." The electric system may be: A; low-tension alternating-current generators for treater load only, *e.g.*, a single-phase generator supplying power (1) to a single transformer-rectifier unit, (2) to two or more units in parallel on the low-tension side, or (3) a multi-phase generator for one or more transformer-rectifier units from each phase. Of these systems A 1 is the most widely used because it isolates each treater circuit from the main circuit and from other treaters, and thus localises all disturbances; the system is highly flexible and is believed to secure maximum dust precipitation and greatest simplicity of control and operation. On the B system low-tension alternating-current currents are taken from mains having a relatively large capacity, compared with the treater demand, for feeding one or more transformer-rectifier units; this system has been adopted in a few, mostly experimental, stations for large power; the first cost is low, but with increase in the number of units the effects of any variations in the supply line on the treater operation, the effects of wave distortion, and the hazard to life and equipment by surgings become greater, while the control becomes more difficult. On the C system high-tension alternating-current mains are directly joined to potential-regulator rectifier-treater sets; the first cost and the floor space required are low, but the liability to interruption of service is great. The transformers must be able to bear the surgings of a treater breakdown, caused chiefly by short circuits between the electrodes. Mechanical rectifiers driven by synchronous motors have answered best; such a rectifier consists of a rotating disc provided with two conducting sectors and four stationary contact shoes alternately connected to the transformer and rectifier. Oscillographs of the treater-volt curves show a practically flat wave; the charged dust particles generally travel at a slow rate, about 1 in. per second, the treater tends to keep the volts constant, and the rectifier practically operates as if it were converting a high-tension alternating current to a nearly constant high-tension continuous current. Although currents of 250,000 volts are mentioned in descriptions of plants, very few treaters actually operate at more than 60,000 volts, and the effective voltage ranged in the treaters examined from 90 per cent. to 97 per cent. of the maximum. With high voltage the oscillations of the electrode wires or chains owing to static attraction become very troublesome; but higher voltages with rigid electrodes would be preferable. The costs of the treaters themselves are very high.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Scotch Steel Trade.—It is too early yet to say definitely how the dramatic suddenness of the cessation of hostilities will effect the steel trade and kindred industries. So far as munitions are concerned it is only when Government makes a pronouncement on the matter that an adjustment can take place. Now that material for the active pursuit of warfare will no longer be required, manufacturers will find themselves in a position to execute the many orders which have already been offered to them, and without doubt a period of considerable activity lies ahead. The recent extensions and additions to plant, rendered necessary by the urgency and magnitude of the Government contracts, will enable the steel-makers to undertake the production of the reconstruction material which will immediately be required and the speedy return of many of their skilled workers will guarantee these new contracts being expeditiously put through. Export will quickly come into its own again, and even already the Scandinavian countries are making demands upon the resources of the West of Scotland. General mercantile business is good, and like to improve every day, the exigencies of the past four years having played havoc with the ordinary consumer and his requirements. Within the past few days prices for export have stiffened up to something like record rates, and angles are now quoted at or about 16*l.* 5*s.* per ton; ship plates run about 17*l.* 5*s.*, with boiler plates at the usual extras. How long rates like these will hold is impossible in the meantime to state—time alone will tell.

Malleable Iron Trade.—The malleable iron makers keep actively employed, and now that export will once more be open to them there is every chance of a considerable increase of trade in the immediate future, even although much of the work which has occupied the entire time and attention of large staffs will now fall into abeyance. Bar iron is still greatly in demand, and heavy outputs are being recorded at all the local producing works, mainly, of course, on home account. Order books are full up, and pressure for delivery in no way eases off.

Scotch Pig-Iron Trade.—The demand for pig-iron could scarcely be heavier, and the smelters are putting all their strength into an endeavour to keep the supply as near as possible to the wants of the consumer, not always an easy task although on the whole fairly satisfactory considering that everyone is only too thankful that any supply is available at all. This attitude on the part of consumers has been of great assistance to the smelters who have had much to contend with in the way of shortage of raw material and scarcity of labour, to mention none other of the many drawbacks. That an improvement may soon be expected is good news to all concerned. Meantime every ton produced goes immediately into use, hematite being especially in demand. The removal of the bar on export will mean a rush on business for which, perhaps, makers are better prepared than they were some time ago.

Coal Economy Exhibition.—The arrangements for the Fuel Economy Exhibition in Trafalgar-square, organised by Lady Rhondda's "Win the War" Committee, are being rapidly completed. The exhibition will be opened on Wednesday, November 27, not November 18 as previously announced, a postponement having become necessary.

The Industrial Reconstruction Council.—A second course of lectures has been arranged by the Industrial Reconstruction Council for next year. The first of these will be given by the Minister of Labour on Wednesday, January 8, the Marquess of Crewe occupying the chair. Other lectures will follow at fortnightly intervals by Judge Edward Parry, Mr. Ernest J. P. Benn, Mr. J. R. Clynes, M.P., Professor A. W. Kirkaldy, and the President of the Board of Education. The chair will be taken on the respective occasions by Lord Balfour of Burleigh, the Bishop of London, Lord Leverhulme, Sir George Riddell, and the Lord Mayor of London. The lectures will again be held, by the kind permission of the Saddlers' Company, in the Saddlers' Hall, Cheapside, at 4.30 p.m. A full prospectus of the series can be obtained from the Secretary, Industrial Reconstruction Council, 2 and 4, Tudor-street, E.C.4, and applications for tickets should be made well in advance.

Industrial Accidents and Lighting.—As showing the value of good lighting in connection with the reduction of accidents, the records of the Travellers' Insurance Company of the United States give the following interesting results. Of 91,000 industrial accidents recorded in 1910, 23·8 per cent. were due directly or indirectly to poor lighting. It should be noted that this record refers only to the accidents investigated by this one Insurance company. For the same period an estimate is made that puts the total industrial accidents of the United States at 500,000 and, on the basis of the Travellers' Insurance Company's percentages, about 125,000 of these accidents were chargeable to the lack of proper illumination eight years ago. Since that time insurance companies have studied lighting conditions in factories in order to classify the risk and, as proper lighting resulted in lower premiums, it was not long before factory managers and their engineers worked out better methods of illumination. The result of this is that during the last two or three years the improvements in lighting have caused a reduction of at least 30 per cent. in accidents which are chargeable to the lack of proper illumination.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—The peculiar character of Sheffield industries will, it is anticipated, make the changing-over period less strenuous in the city of steel than in many of the other large centres of industry. Manufacturers engaged in the staple industries believe that they will be able to switch off from munitions to the ordinary requirements of trade with a minimum of delay and disturbance. The demand for Sheffield's products will be intensified during the reconstruction period, and whilst there will necessarily be some disturbance and dislocation, a few weeks should see the great firms who have done so much to feed our victorious armies in full swing in more peaceful pursuits. Notwithstanding the inflated prices, the demand for iron and steel, manufactured and otherwise, will be enormous for years to come. Railway material, shipbuilding requirements, tramway and colliery stores are badly needed. There has been little renewal of railway track, locomotive and rolling-stock during the past four years. Tramways are in much the same position, and both are prepared to take all the steel material available and place huge orders where there are prospects of reasonably early delivery. The shipyards, too, are awaiting supplies, while agricultural and garden requirements are growing increasingly heavy. These industries form a substantial portion of Sheffield's trade, and are branches which can be turned from war work with a minimum of dislocation. In the lighter trades there are millions of pounds' worth of orders for all over the world which have been held up by Government restrictions, and these, it is reasonable to anticipate, will now be largely removed. During the past week or so there has been some attempt to cancel orders for direct war work, but this has not greatly concerned the firms affected, as the material can be readily used in other branches of trade which will spring into activity with the cessation of hostilities. The only great difficulty will be the finding of employment for the thousands of unskilled workers, chiefly women, who have been engaged in the large shell factories. Plans are in existence to obviate their immediate discharge. The early days of the past week have been universally observed as a holiday by the workmen.

South Yorkshire Coal Trade.—Although naturally peace rejoicings have seriously affected the output of the pits in South Yorkshire, the colliers are to be congratulated on their patriotic answer to the call that they should as far as possible continue at work. On Monday most of the pits shut down for a portion of the day, but on Tuesday morning fully 50 per cent. of the men were at work and affairs became normal later in the week. The fuel situation is still precarious, and coalowners express the hope that the demobilisation of colliers will be immediately tackled by the Ministry. The demand for local works will show no diminution once the changing-over period is past, and shipping requirements, which have been limited for so many years, will become immediately pressing. The wagon difficulty is a serious one, there being a general shortage of stock. Business in domestic fuel during the week has been steady, merchants realising the necessity of normal supplies being maintained. Stocks, however, are low, and by no means equal to the demand made upon them during the recent severe weather. The quotations are: Best branch hand-picked, 27*s.* to 28*s.*; Barnsley best Silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.* 6*d.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

Standardisation of Rubber Tyres.—The British Rubber Tyre Manufacturers Association, Limited, whose general secretaries are Messrs. W. B. Peat and Co., 11, Ironmonger-lane, E.C. 2, have issued a pamphlet dealing with a scheme for standardising all tyre sizes. It is proposed to adopt 10 cycle tyres instead of 33 different varieties, 6 motor-cycle tyres instead of 22, 4 light car tyres instead of 8, 10 motor-car tyres instead of 63. Solid rubber tyres are similarly dealt with. The pamphlet enters into the details of the scheme for each class of tyre and also covers the valves. Although the scheme as printed has been adopted by the British tyre manufacturers, any reasonable modifications may yet be made if good grounds be shown for any alteration before the scheme goes to the Technical Committee of the motor industry, for final report to the British Engineering Standards Association.

Irish Concrete Ships.—At Warrenpoint, Carlingford Lough, a new yard for the building of ferro-concrete vessels, the only one of its kind in Ireland, has been constructed. Two Belfast firms, Messrs. J. and R. Thompson and Messrs. McLaughlin and Hawey, have joined forces for shipbuilding purposes. A site was acquired consisting of a narrow strip of land, bounded on one side by a railway siding and on the other by the estuary. A deep-water quay, beside which steamers drawing 14 ft. can berth, adjoins the site. The greater portion of this will be used as a fitting-out berth. A crane has been erected, a large fitting shop has been built alongside, and this is to be equipped with modern machine tools for dealing with repairs and fitting-out. There are also joiners' shops, a smithy, complete crushing and screening plant, mould lofts, cement stores, concrete mixer house, and a full range of offices. Narrow-gauge rails are laid down all over the yard to facilitate handling of materials. Nine months ago the site was a bleak stretch of barren beach. To-day it finds employment for 400 workers. Orders are on hand for Admiralty barges.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Holiday making is general, traders showing little inclination to discuss business. Most of the blast furnaces have been put on to slack blast to enable the furnacemen to enjoy a brief well-earned holiday. This will, of course, once more, cause an unduly large production of the lower qualities of pig-iron, which, after having been very plentiful, until quite recently, had become less easy to obtain. Truck shortage is still complained of, but steamer tonnage is coming forward fairly well, and shipments both to coastwise customers, and to the Allies are good. Expansion of transactions with neutrals is looked for, inquiry being already very heavy. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry, and No. 4 forge were all quoted 95*s.*, and No. 1 was 99*s.*; whilst for shipment to France and Italy, No. 3 and the lower qualities were 122*s.* 9*d.*, and No. 1 was 127*s.* 9*d.*

Hematite Iron.—There is no new feature of moment in the East Coast hematite branch. Subject to some delay due to the truck shortage, the steady pressure of the home demand is adequately met, and with steamer tonnage coming forward fairly well, exports to the Allies are quite good. The whole position in this department has been very considerably eased by the greater use of basic iron for steel-making. Nos. 1, 2 and 3 hematite are 122*s.* 6*d.* for home use, and 147*s.* 6*d.* for export to France and Italy.

Manufactured Iron and Steel.—Holidays at the finished iron and steel works have reduced output, and reduction of Government orders for shell steel has also checked make, so that a period of relative slackness in certain branches will ensue. Demand for shipbuilding material and constructional steel, however, shows no abatement, and on the whole, works in this district promise to continue well employed during the period of transition due to cessation of hostilities. The following are among the principal market quotations in the home trade:—Common iron bars, 14*l.* 15*s.*; best bars, 15*l.* 15*s.*; best best bars, 16*l.* 15*s.*; best best best bars, 17*l.* 15*s.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 17*s.* 6*d.*; iron ship rivets, 21*l.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel strip, 17*l.* 10*s.*; steel hoops, 18*l.*; and heavy steel rails, 10*l.* 17*s.* 6*d.*—all f.o.t. at works. Whilst there are no fixed prices for export, they may be given as approximately 40*s.* above home quotations.

Coke.—Supply of coke is hardly sufficient to meet all demands. The very heavy local needs, however, are receiving adequate attention. Medium blast-furnace kind is 33*s.* at the ovens, and quality low in phosphorus is 35*s.* 6*d.* at the ovens. Quantity of coke allowed for shipment to neutrals is small, and is quickly taken up. For such trade both foundry and furnace quality find a ready market at 65*s.* f.o.b.

BOILERS (CONTROL) ORDER, 1918.—No further permits for the sale by public auction of any boilers, to which the above-mentioned Order applies will be issued, and therefore no sales by auction of such boilers may be held.

SHIPYARD GENEROSITY ON THE TYNE.—The workmen at all the shipyards, ship-repairing works and engine shops on the Tyne have been generous supporters of war charities in the past four years. The workmen and staff of the Jarrow and Hebburn shipyards of Palmers, Limited, for example, have subscribed 30,000*l.* to war relief funds, in addition to large sums raised for hospitals and other charities. The Jarrow yard has also subscribed nearly 800*l.* to provide gifts for Jarrow soldiers who gain distinctions in the war. Mr. George Jackson, plater, is chairman of this fund.

ELECTRIC STEEL FURNACES.—In the course of a paper which he read on the 9th inst., before the Staffordshire Iron and Steel Institute, Mr. F. J. Moffett, B.A., M.I.E.E., stated that at the end of the year 1917 the electric furnaces installed in the United Kingdom were as follows:—

Héroult	46, varying from 1½ tons to 10 tons.
Greaves-Etchell...	31, varying from ½ ton to 12½ tons.
Electro Metals ...	27, varying from 1½ tons to 10 tons.
Rennerfelt ...	8, varying from ¾ ton to 2½ tons.
Stobie	6, varying from 5 tons to 15 tons.
Other makes ...	22.

Of these 140 furnaces, nearly one-half were in the Sheffield and Rotherham district. It was evident from the list that the arc type of furnace had established its superiority from a commercial point of view. The induction furnace was now very rarely adopted in this country for steel refining. The standard sizes of furnaces with the transformer capacity and the approximate units per ton of finished steel were thus stated by the author:—

Size.	Transformer Capacity. Kw.	Units per Ton.
25 cwt.	300	850
2½ tons	500	800
5 tons	800	750

The decrease in units per ton does not go on indefinitely; when the capacity of 15 tons is reached, the units per ton appear to attain their minimum value. We may add that there are at the present time one or more 25-ton furnaces now under construction.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—In view of the announcement of the signing of the terms of the armistice and the consequent cessation of work in the coalfields the market this week has been absolutely devoid of any interest. Collieries are well stemmed, but, as indicated, the production of coal has been very greatly impeded and there are at present hardly any supplies available. The miners were given one day's holiday, but the majority have abandoned themselves to rejoicings and there has been very little work during this week.

Newport.—There is a keen demand for Monmouthshire coals, especially household descriptions, but, owing to the men celebrating peace, the production has been very low and totally inadequate to meet the demands. The result is that stocks have been pretty well all secured and the shortage will soon become acute.

Colliery Surfacemen's Hours.—The agitation with reference to securing an eight-hour day for the whole of the colliery surface workmen is still proceeding. A ballot has been taken of the men who are members of the Monmouthshire and South Wales Enginemen's and Craftsmen's Association, with the result that an overwhelming majority has voted in favour of tendering notices in order to secure their demands. The Miners' Federation have also convened another conference to be held next Saturday to deal with the matter, and it is feared that some trouble may be experienced very shortly in dealing with the dispute.

PROPOSED STATE CONTROL OF ELECTRICITY PRICES.—The question has been to the fore in Sweden, as to whether it would not be advisable to introduce State control of the prices charged for electric energy. The matter has been before the Royal Waterfalls Board, who have declared the introduction of State control; at the same time the State is urged to push forward the generation of current as much as possible, which by the State, in a different way, will exercise a certain control of the prices in question.

SECOND-HAND MACHINE TOOLS, WOOD-WORKING MACHINERY AND TREADLE LATHES.—The Minister of Munitions announces that in future second-hand machine tools, second-hand wood-working machinery and second-hand treadle lathes may be bought and sold without the sanction of the Ministry and without restriction as regards price. This suspension of regulations, however, does not in any way affect the position with regard to new tools, to which the regulations still apply in their entirety. A further notification concerning new tools will be issued in the course of the next few days.

"ALL THE WORLD'S AIRCRAFT, 1918."—This publication, which was founded by the late Mr. Fred. T. Jane, editor and founder of "Fighting Ships," now enters its ninth year of issue, and is edited by Mr. C. G. Grey. It is published by Messrs. Sampson Low, Marston and Co., Limited, 100, Southwark-street, S.E. 1, at the price of 25*s.* net. Its contents are explained in its title. It opens with a very useful aeronautical dictionary and diagrams, a glossary of technical terms, followed by tables of records, data on war flying in 1917 and on the aeroplanes of the various nations, arranged alphabetically. Special chapters deal with the world's air ships, the world's aero-engines, the world's historical aircraft, &c. The book is profusely illustrated by colour blocks, diagrams and designs, is most nicely got up, and will prove both interesting and useful for reference purposes.

EXTENSION OF GERMAN STEEL AND IRON WORKS.—The Rhenish Steel Works at Duisburg-Meiderich continue their policy of extension either by absorption of iron works and mines or by other arrangements which generally end in the same way. The last move is co-operation with the iron works of Wuppermann, Schlebusch-Manfort, and Felser and Co., Cologne-Kalk. These two concerns, which are among the oldest in the district, have for some six years been working in conjunction with the Rombach company, and it is no doubt with a view to the peace industry that the Rhenish Steel Works have made the arrangement, half-finished products being one of the main export specialities of the Steel Union before the war, more especially as far as England was concerned. The German Luxemburg Mining Company and Iron Works have secured the use of additional iron ore deposits in the Altenkirchen district, to be known under the name of the Union mine.

THE GERMAN PETROLEUM INDUSTRY.—The very substantial profits which the existing well-established petroleum concerns have earned during the year has given a great impetus to the starting of new ventures in this direction, which are not altogether favourably viewed by experts. Amongst others the Hannoverian oil district is to the fore in this connection, although before the war the chances of any material extension of this industry was looked upon as unlikely. Among new concerns there are the Hannovarian Petroleum Undertakings, the Hanseatic Petroleum Undertaking and the Imperator Company. German enterprise is still more to the front in Galicia; these ventures are on a larger scale and often take the shape of syndicates. Thus the German-Austrian Naphtha concern has a capital of 7,000,000 marks, in 2,800 portions, and another new venture is the Syndicate Austrolex. The syndicate form possesses several advantages, official sanction is not needed, no stamp duties have to be paid and no publicity is called for. Undertakings like the Albingia, the Ballia, Arminia and Hibernia help to swell the list, and there is a superabundance of money for any new venture.

NOTICES OF MEETINGS.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, November 15, at 6.15 p.m. Address to be given at the general meeting: "Scientific Research in connection with Marine Engineering and Shipbuilding," by Sir Frank Heath, K.C.B., Secretary to the Committee of the Privy Council for Scientific and Industrial Research.

THE BRITISH FOUNDRYMEN'S ASSOCIATION; LANCASHIRE BRANCH.—Saturday, November 16, at 6.30 p.m., in the Heginbottom Technical School, Ashton-under-Lyne. Mr. W. H. Cook, of Heaton Chapel, will take the chair, and also speak on "A Few Everyday Foundry Problems"; Mr. W. H. Meadowcroft, of Newton Heath, will also speak on "The Objects and Aims of the British Foundrymen's Association."

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 19, at 5.30 p.m. Paper to be submitted for discussion: "The Tata Hydro-Electric Power Supply Works, Bombay," by Mr. Robert Bateson Joyner, C.I.E., M.Inst.C.E.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, November 19, at 5.30 p.m., at the House of the Royal Society of Arts, John-street, Adelphi. The following paper will be read: "The Motor Fuel Problem," by Mr. W. R. Ormandy. The chair will be taken by the president, Mr. Charles Greenway.

THE ROYAL SOCIETY OF ARTS.—Wednesday, November 20, at 4.30 p.m., Inaugural Address of the 165th session, by Mr. Alan A. Campbell Swinton, F.R.S., chairman of the council, on "Science and the Future." Thursday, November 21, at 4.30 p.m.—Colonial Section—"The Present State of the Pacific Islands," by Sir Everard im Thurn, K.C.M.G., C.G., LL.D. Sir Charles Lucas, K.C.B., K.C.M.G., will preside.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, November 20, at 5 p.m., at 70, Victoria-street, Westminster. Papers to be read: (1) "The Larger Relations of Climate and Crops in the United States," by Mr. R. de C. Ward, F.R.Met.Soc.; (2) "Soundings with Pilot Balloons in the Isles of Scilly, November and December, 1911," by Captain C. J. P. Cave, R.E., F.R.Met.Soc. and Mr. J. S. Dines, M.A., F.R.Met.Soc.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, November 20, at 8 p.m., at the Royal Institution, Colquitt-street, when a paper will be read by Mr. Algernon E. Berriman, O.B.E., entitled "Education in Relation to Industry, and with Particular Reference to Engineering."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, November 21, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. "The Use of High-Pressure and High-Temperature Steam in Large Power Stations," by Mr. J. H. Shaw, Associate Member.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, November 21, at 5.30 p.m., at the rooms of the Geological Society, Burlington House, Piccadilly London. The following papers will be submitted for discussion: "Refining Gold Bullion with Chlorine Gas and Air," by Mr. R. R. Kahan, B.Sc.; "Effect of Heating and Heating and Quenching Cornish Tin Ores before Crushing," by Mr. Arthur Yates, Member; "The Development of Galena Flotation at the Central Mine, Broken Hill," by Mr. Rasmus J. Harvey, Associate.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Saturday, November 23, at 6.30 p.m., a joint meeting with the British Foundrymen's Association, will be held at the Technical School, Suffolk-street, Birmingham, when Mr. E. H. Broughall, of Coventry, will read his paper on "Permanent Moulds."

NEW ELECTROLYTIC INDUSTRY IN SWEDEN.—A company has been formed under the style of the Electro-Alkali Company, with a view to manufacturing chloride of lime and other products. The process will be based on the most modern Siemens and Halske methods and the output of chloride of lime is calculated at some 3,000 tons to 4,000 tons annually. The new company is negotiating about a suitable site for the works.

SHIPBUILDING ACTIVITY IN DENMARK.—The provincial Danish shipyards continue to extend their scope and enlarge their plant; for this purpose fresh capital is needed, and three yards are simultaneously increasing their capital, the Marstal Steel Shipbuilding Company, with 500,000 kroner, the Vulkan yard at Korsör also with 500,000 kroner, and the Vindö yard, Hobro, with 700,000 kroner.

NORWEGIAN SHIPBUILDING CONTRACTS WITH HOLLAND.—Norwegian owners have ordered seven good-sized motor vessels in Holland, having an aggregate tonnage of 38,450 tons, in addition to which five vessels, of an aggregate tonnage of about 6,600 tons are in course of construction, and one of 2,850 tons and one of 3,000 tons, the latter of which is being fitted with a new type of motor developing 2,000 h.p.

THE NOBEL BROTHERS NAPHTHA PRODUCTION COMPANY.—This large concern, from what may be gathered, has now been nationalised, but it appears uncertain as to whether the taking over by the State has been effected prior to or after July 1. This question is apparently one which greatly interests the German shareholders, as it affects their chances of receiving the money for the value of their shares and the dividends for the years 1914 to 1917.

30,000-TON FLOATING DOCK IN THE BLACK SEA.

BUILT TO THE DESIGNS OF MESSRS. CLARK AND STANFIELD, ENGINEERS, WESTMINSTER, BY THE RUSSIAN SHIPBUILDING COMPANY, NICOLAIEFF.

(*For Description, see Page* 551.)

Fig. 1. LONGITUDINAL SECTION.

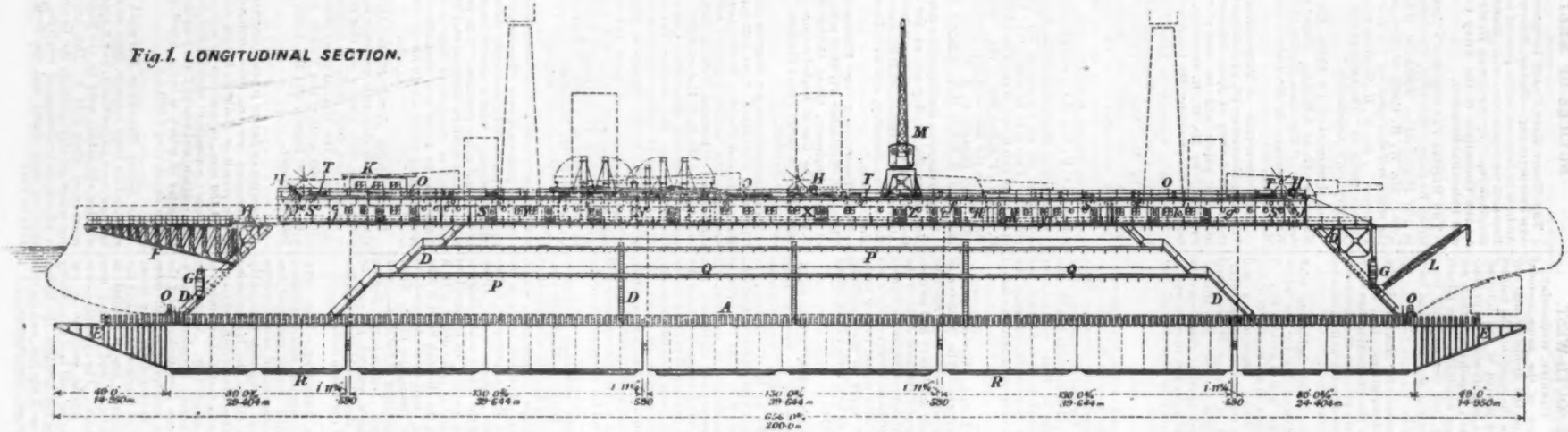
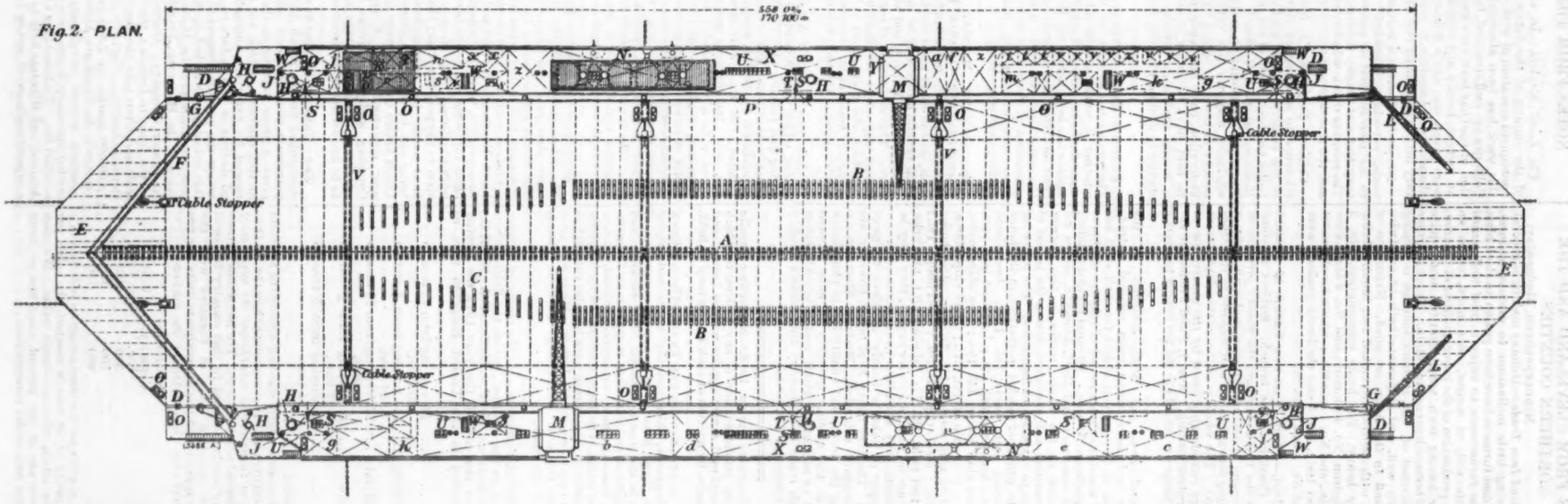


Fig. 2. PLAN.



A. Central keel blocks. B. Side keel blocks. C. Sliding bilge blocks. D Accommodation ladders. E. End platforms. F. Flying gangway. G. Roller fenders. H. Capstans and fairleads. J. Capstan engine rooms. K. Valve house. L. Derrick cranes. M. Travelling cranes. N. Boiler rooms. O. Bollards. P. Rubbing timbers. Q. Stages. R. Troughs. S. Pump motor rooms. T. Electric cluster lights. U. Skylights. V. Plating between pontoons. W. Companions. X. Generating and engine rooms. Y. Crew's Russian baths. Z. Stores. *a*. Paint and lamp stores. *b*. Workshops. *c*. Smithy. *d*. Coppersmiths. *e*. Carpenters and joiners. *f*. Laundry. *g*. Crew's lavatory, *&c.* *h*. Warrant and petty officers' lavatory. *j*. Officers' lavatory, *&c.* *k*. Crew's mess rooms. *m*. Warrant and petty officers' mess. *n*. Officers' mess. *p*. Officers' baths. *q*. Chief engineer's quarters. *r*. Chief constructor's cabin. *s*. Officers' cabins. *t*. Warrant and petty officers' cabins. *v*. Crew's cabins. *x*. Officers' galley and pantry. *y*. Warrant and petty officers' galley. *z*. Crew's galley and pantry.

TEMPLETS, JIGS AND FIXTURES.

(*For Description see Page* 543.)

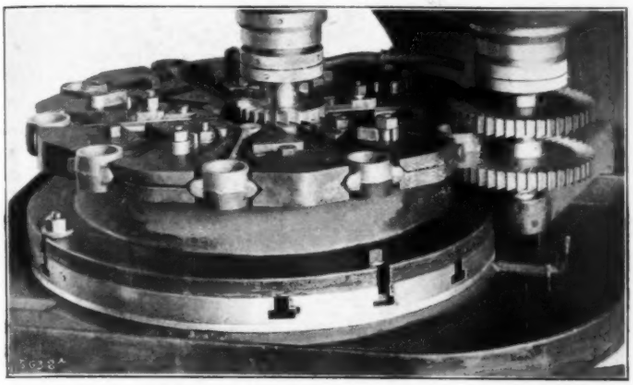
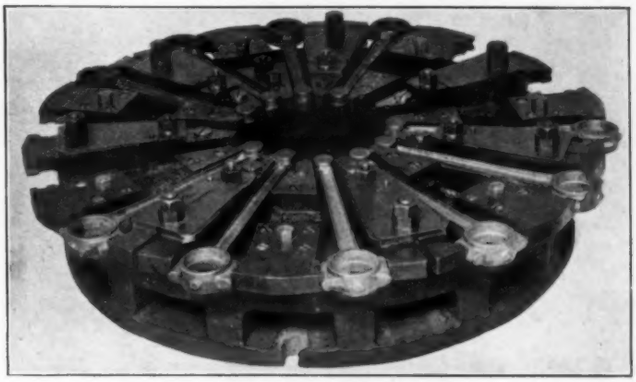


Fig. 484.



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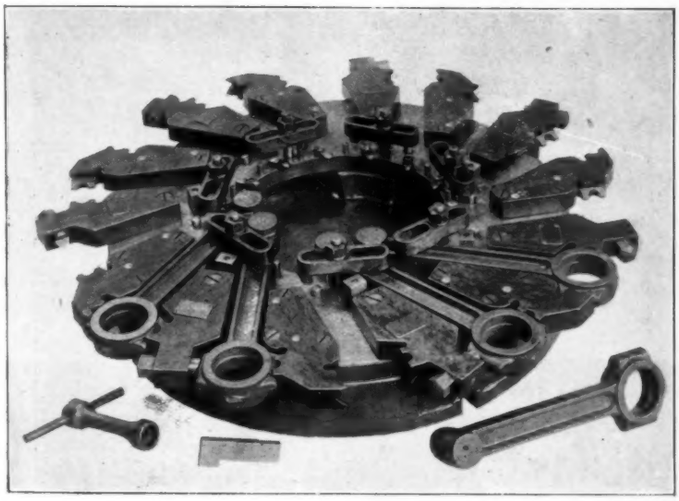

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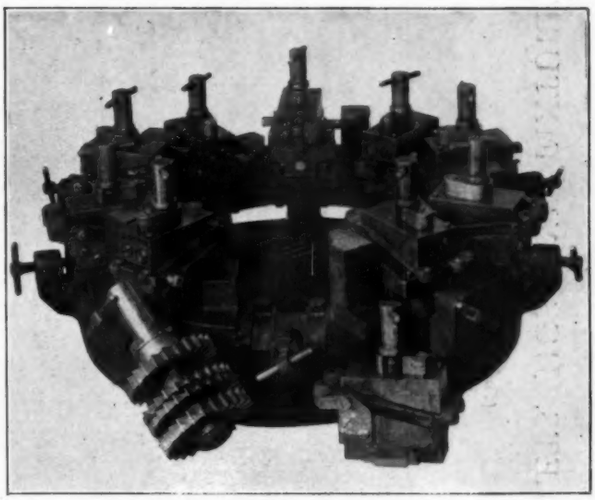
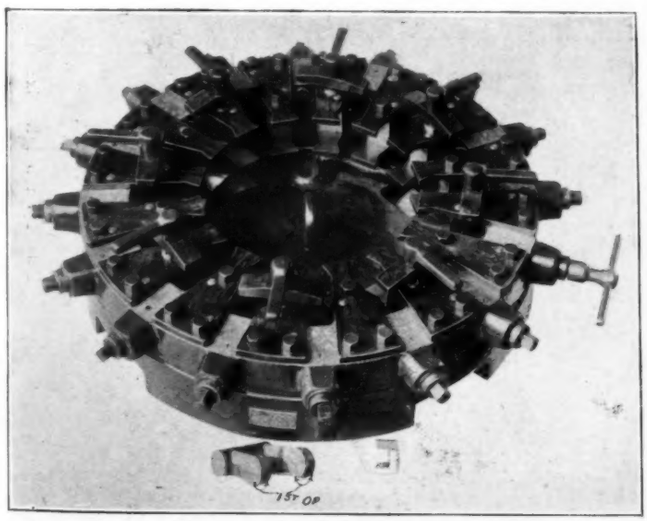


Fig. 487.



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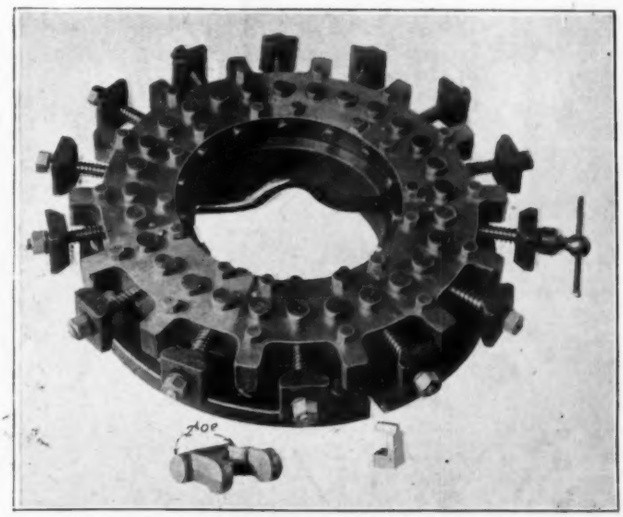

Fig. 489.

Figs. 484 to 489. Examples of Continuous Milling Fixtures by the Becker Milling Machine Company, Hyde Park, Mass., U.S.A.

(*To face page* 544.)

TEMPLETS, JIGS AND FIXTURES.

(*For Description, see Page* 543.)

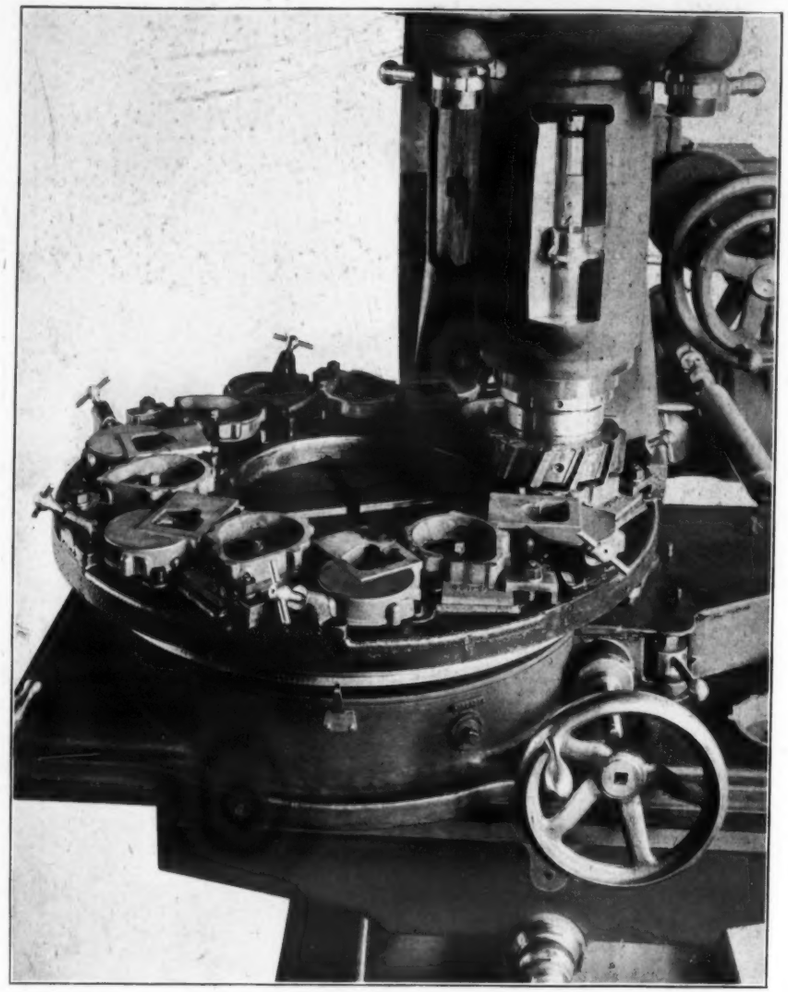

FIG. 490.

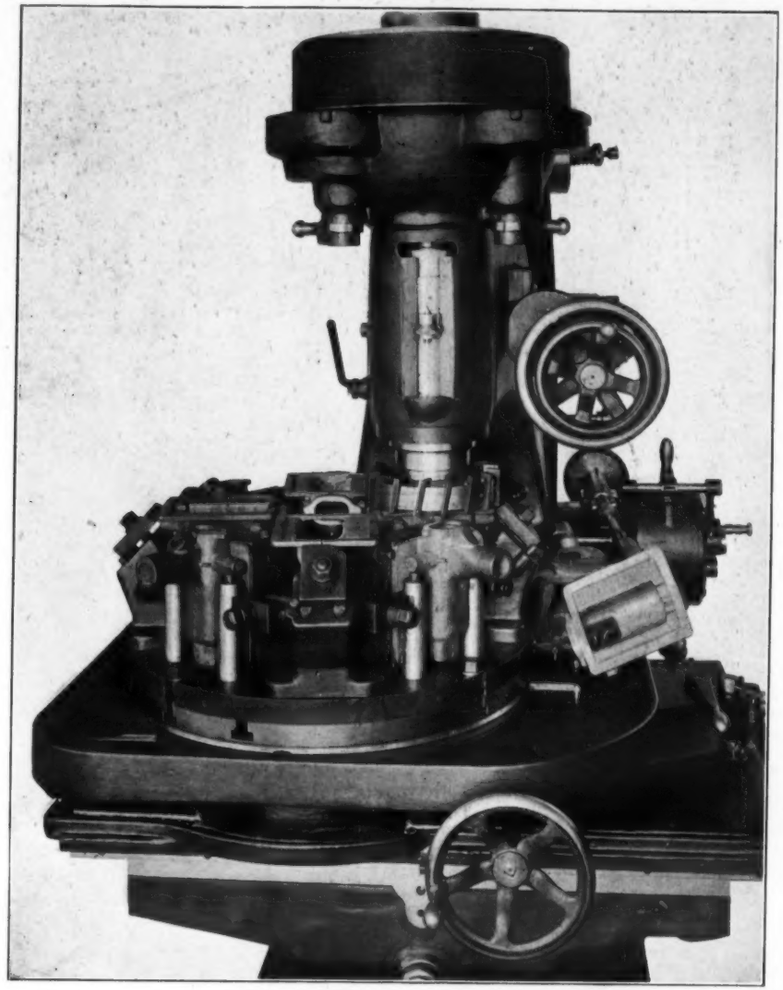

FIG. 491.

FIGS. 490 AND 491. EXAMPLES OF CONTINUOUS MILLING FIXTURES BY THE BECKER MILLING MACHINE COMPANY, HYDE PARK, MASS., U.S.A.

TEMPLETS, JIGS AND FIXTURES.

(*For Description, see Page* 543.)

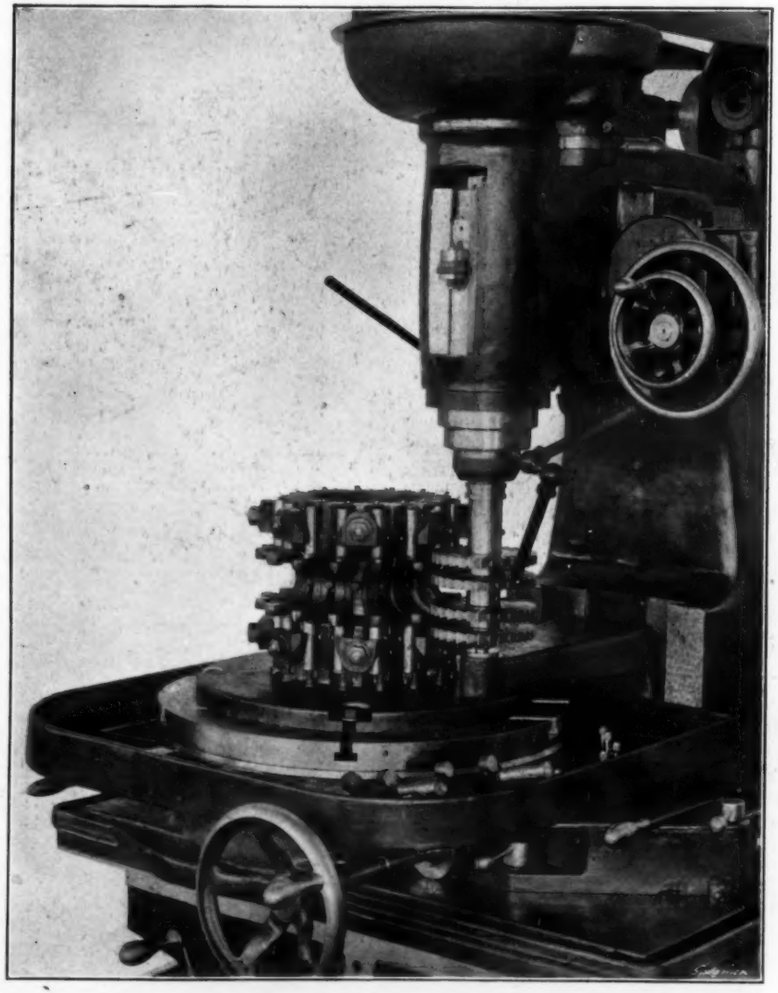

FIG. 492.

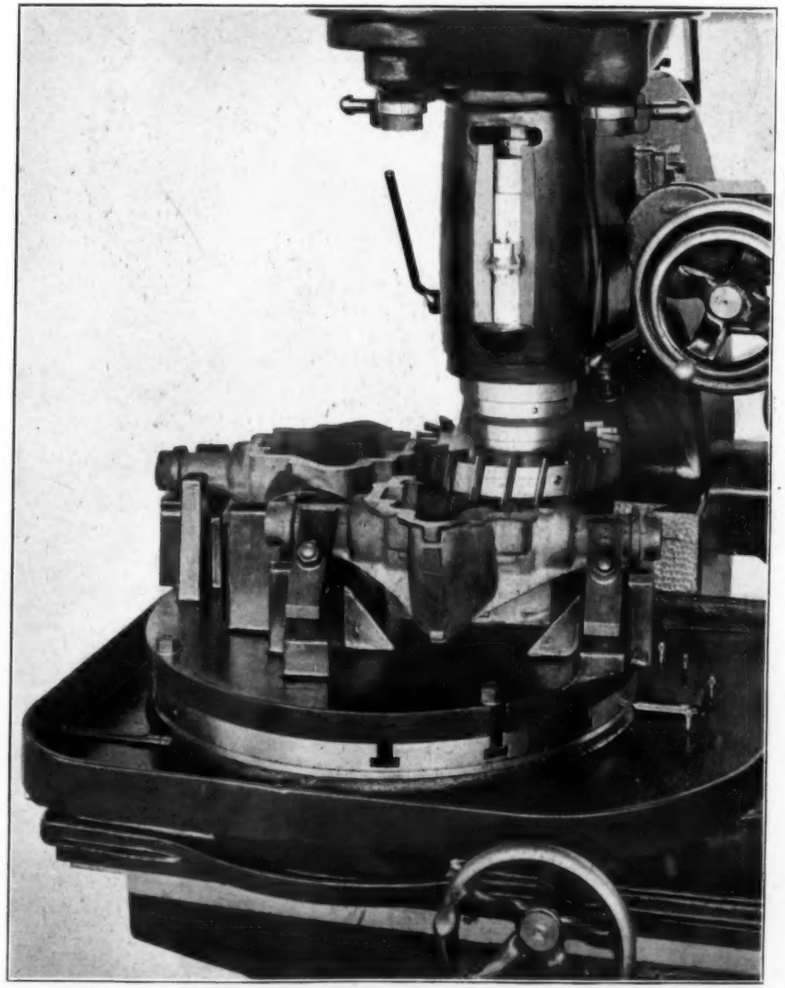

FIG. 493.

FIGS. 492 AND 493. EXAMPLES OF CONTINUOUS MILLING FIXTURES BY THE BECKER MILLING MACHINE COMPANY, HYDE PARK, MASS., U.S.A.

TEMPLETS, JIGS AND FIXTURES.

(*For Description, see Page* 543.)

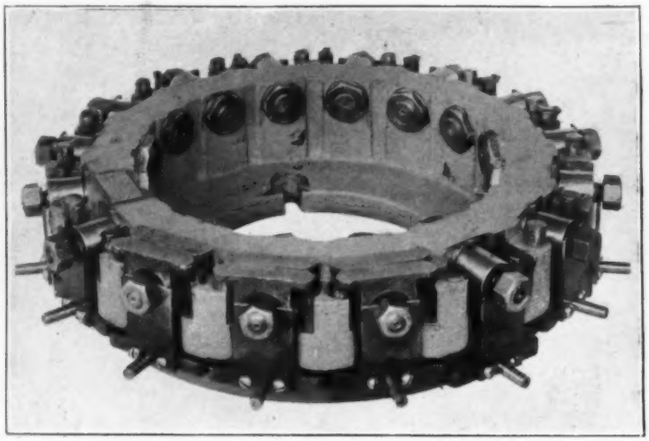

FIG. 494.

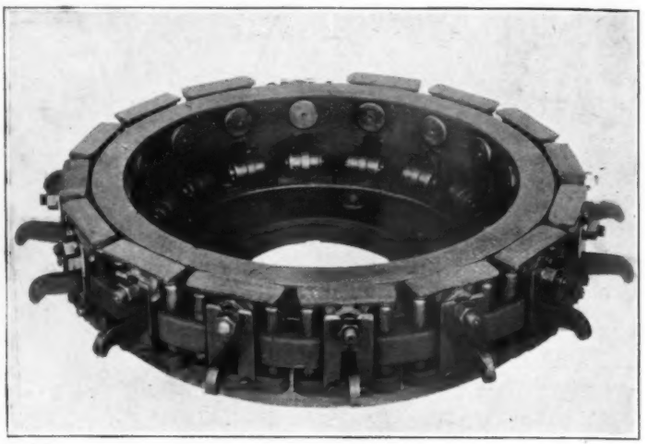

FIG. 495.

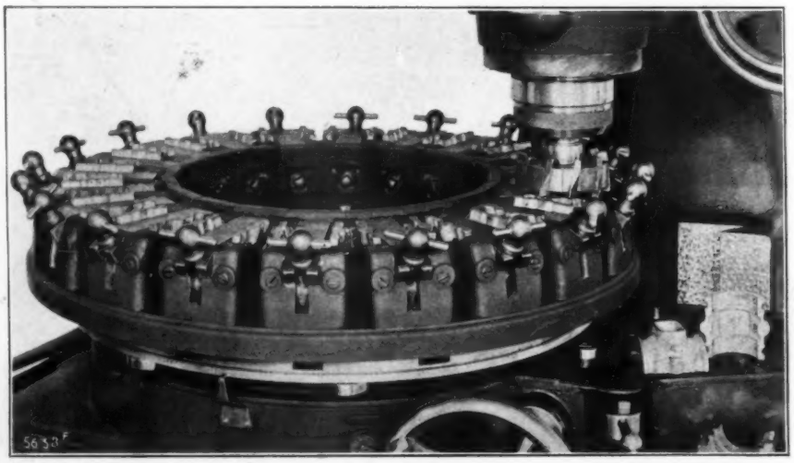

FIG. 496.

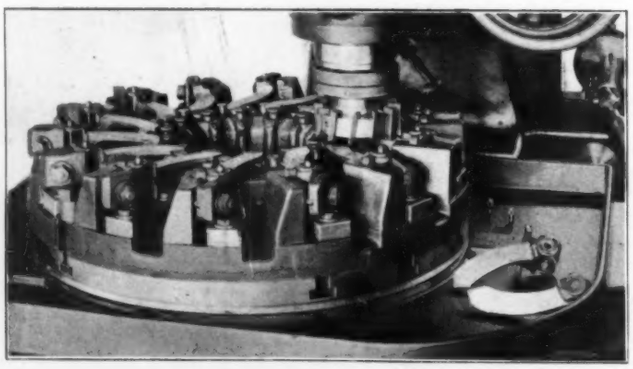

FIG. 497.

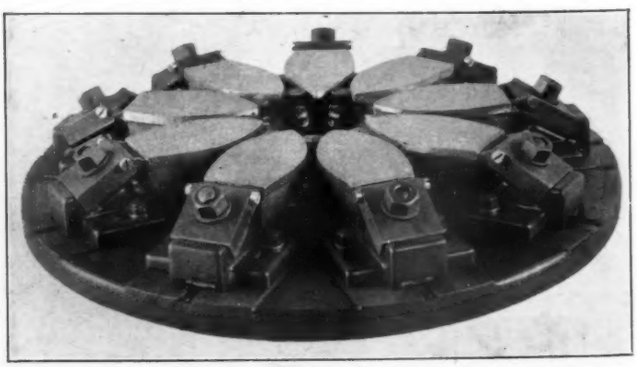

FIG. 498.

FIGS. 494 TO 498. EXAMPLES OF CONTINUOUS MILLING FIXTURES BY THE BECKER MILLING MACHINE COMPANY, HYDE PARK, MASS., U.S.A.

(*To face page* 545.)

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The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than Monday morning.

SUBSCRIPTIONS, HOME AND FOREIGN.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3063 and 3506 GERRARD.

CONTENTS.

	PAGE
Templets, Jigs and Fixtures.—No. XV (*Illus.*)	543
Falling Weight Tests on Railway Tyres (*Illus.*)	545
State Electricity, Electricity Supply, Combines, &c.	547
The Design and Construction of Diesel Engine Fuel Pumps (*Illus.*)	549
Construction and Trials of 30,000-Tons Black Sea Floating Dock (*Illus.*)	551
The late Mr. William Llewellyn Preece	552
"Coal Saving by Scientific Control of Steam Boiler Plant"	552
Galileo	552
"The Technics of Magneto-Magnets"	553
Women in the Drawing Office	553
Standard Concrete Barge for Use on the New York State Barge Canal (*Illus.*)	554
Notes from the North	556
Notes from South Yorkshire	556
Notes from Cleveland and the Northern Counties	557
Notes from the South-West	557
Notices of Meetings	557
The Engineer in the War	559
The Dynamical Theory of Electric Engines	560
Alsace-Lorraine and German Industry	561
The Occlusion of Gases by Metals	562
Notes	564
Industrial Notes	565
The Cement Industry	565
Problems of Reconstruction	566
German Steel Industry War Profits	566
Waste Heat for Steam Generation (*Illus.*)	567
The Standardisation of Tests for Refractory Materials (*Illus.*)	569
Gases Occluded in Steel	572

With Four One-Page Plates of TEMPLETS, JIGS AND FIXTURES.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 8d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers; therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 557.

ENGINEERING.

FRIDAY, NOVEMBER 15, 1918.

THE ENGINEER AND THE WAR.

For the first time for nearly four and half years we write free from the sense of everything being overshadowed by war and of being subservient to the single end of attaining victory. The moment for which we have all waited so long, and which we have sometimes thought was near, only to recognise that it had again been deferred to some distant date which we could not specify, occurred last Monday morning, when the High Command of the German Army accepted the rigorous terms of the armistice laid down by the Allies and the United States. These are so defined that there is no chance of the enemy refusing the conditions of the peace we shall dictate, and we are at liberty to take a rapid survey of what the engineer has done in attaining this great object.

When, in seeking the cause of the late war, we carry our inquiries backward, we come at length to the imposing figure of George Stephenson. When he showed the world the wonderful power of the railway as a medium of transport he gave to ambitious rulers and enterprising peoples a fresh means of pushing their influence beyond their own frontiers, and of bringing other lands under their control. The lesson did not strike home in this country, for the sea furnished us with a highway all over the globe, and our merchant shipping already penetrated into every harbour. But nations with vast back areas and great distances found in the railway the means both of control and of exploitation. The transcontinental lines of America, both in the States and Canada, brought into cultivation great areas of land, at the same time keeping all the people loyal to one government and united in one interest. Similarly the Trans-Siberian Railway connected Europe with the Pacific, and offered an outlet for great numbers of Russians who were starving on the exhausted soil on which they were born. It was also a signal to China and Japan that Russia was determined to maintain that distant area against all encroachment as long as she could, and that she would probably miss no chance of enlarging her borders. Germany had no outlying areas of her own to exploit, but she saw her chances in the weak and decadent east. With fine foresight she constructed the railways from Constantinople to Baghdad, and linked them up to the corresponding lines in Europe. There was a clear run from Hamburg to the Persian Gulf if only a political hold could be established over the intervening countries. The Turk was the first to be won over. "My Friend the Sultan," entertained the Kaiser, and speeded him forth on his pilgrimage to Jerusalem. German officers drilled the Sultan's army, and German financiers found money for economic development. But Abdul the Damned was too nauseous a morsel even for Turkish stomachs to digest, and he was driven from the throne. In the confusion which attended the change, Austria was prompted to seize Bosnia and Herzegovina. One link in the chain of communications was thus rendered secure, and when Russia showed signs of intervening she was reminded that Germany lay on her flank and was the firm ally of Austria.

The Young Turks came in full of protestations of liberal ideas, and undertook to regenerate the country. But their actions recalled Milton's caustic remark that the new presbyter was the old priest writ large. Their liberalism was no more tolerable than Abdul's tyranny, and they soon fell under German control. A country possessing great wealth, which could be spent without any rigid parliamentary control, had no difficulty in dealing satisfactorily with the new rulers. Both ends of the Baghdad Railway were again secure, but between Bosnia and Turkey there was a length of rail in the Balkans, a land which has always and ever been in a state of unrest and regarding which Germany could feel no certainty. Serbia, Bulgaria and Greece resolved to take advantage of the unsettled conditions at Constantinople to free themselves and their friends from the new Turkish tyranny, and they very nearly drove their old oppressors out of Europe altogether. But German influence sowed dissension between the victors, and while they were fighting among themselves and weakening their influence, the Turk recaptured a part of his lands. The King of Greece was about the same time assassinated, and his son, who was under the influence of his wife, a German princess, reigned in his stead.

In the early part of 1914 the Berlin-Baghdad Railway was almost entirely in hands that were under the control of Germany. It ran through Austro-Hungary, Bosnia, Serbia, a small part of Bulgaria, Turkey and Asia Minor. The only independent part was Serbia, which bitterly resented the German and Austrian interference at the close of the last war. Further, the Serbians are a stiffnecked people. For a thousand years they have lived with their hands on the sword. They fought long and frequently first with the Greeks, when the latter held Constantinople and later with the Turks. They were always ready for a fight with their neighbours, and by no means averse to a scrap among themselves. Clearly the Berlin-Baghdad Railway would never be secure while they controlled a part of it, and therefore it was determined that they should be bled to the white, and then ground under the heel of Austria. An excuse was easily found—reasons for fighting are as plentiful in the Balkans as in Donnybrook Fair—and an ultimatum was issued which meant national extinction. Serbia, cowed for once by her danger, humbled herself to the dust. She accepted every condition compatible with her being a sovereign State, and she offered to submit the remainder to international arbitration. But it was just her sovereignty that constituted a blot on the fair prospects of the eastern policy of Germany and it had to be wiped out. It proved a more difficult business than had been anticipated, and twice Austria reeled back from the attack. It needed the better methods and more efficient organisation of Germany to overrun the country and attain the object for which the war was commenced. For a short time the Kaiser was in supreme command from Hamburg to Baghdad, and the German nation congratulated itself that whatever might happen in the West they would more than recoup themselves in the East. The engineer had constructed for them a channel along which not only trade, but German kultur and German domination could flow.

But if it was a British engineer who first planted the seed from which the war arose, there were many others who, during the past four years, have done splendid work to win it. The War Office has never realised the value of the mechanical engineer. In view of the smallness of our army he ought to have been given a free hand so that each man might have had his powers multiplied manifold by machinery, just as has been done in manufacture. But we were behind Germany in many, if not in all, respects. We were almost destitute of machine guns, we had no seige guns such as those which smashed the Liege forts and opened the road into

France, we were deficient in aeroplanes, motor transport was unorganised, our airships were experimental, and we had no efficient means of defence against submarines. Now, on the eve of the Peace Conference, we are the equals of Germany in every respect, and her superior in most. We have machine guns and to spare; our heavy artillery answers every demand upon it, and if we are told we have no guns such as bombarded Paris from an unheard of range, we can reply, like the Roman, that our weapons are long enough to reach the heart of our enemy and have done so. In aeroplanes we are preeminent, and have cleared the sky again and again. In speed, in manœuvring ability, in weight-carrying capacity the machines designed and constructed by British manufacturers can bear comparison with any, and in the hands of British pilots they have often secured victory over odds that were most disproportionate. The output of motor transport has been a triumph of the manufacturing engineers of this country. As we mentioned last week we commenced our recent advance, after our setback in the spring, with thousands of vehicles out of repair, and with very insufficient means of dealing with them, and yet we have kept touch with the enemy day by day, supplying our men with food and munitions, carrying road metal and girders for mending roads and railways, and advancing our guns, without delay or failure. We have only to contrast this with the inability of the Germans to maintain their advance after their easy overwhelming of our thin line in the spring. As they got further and further from their base their advance grew slower and slower, and finally ceased, the stoppage being largely due to the insufficiency of their transport. As for the Zeppelins, which for a time caused considerable suffering and loss of life in this country, our engineers found a reply in the incendiary bullet. After the War Office had been convinced of its value the Zeppelin menace suffered speedy eclipse, and it was not long before the use of these expensive monsters was abandoned except for scouting purposes at sea.

Possibly the greatest of the engineer's contributions towards winning the war was the tank. It was entirely a new military engine, and at its appearance it spread dismay among the enemy. It broke down the most difficult obstacle to a charge—the barbed wire fence—and it routed out machine-gun nests which were proof against direct attack by infantry and difficult to reach by artillery. The tanks have saved tens of thousands of British lives, and alike in the conception, design and the secrecy of their construction have reflected credit on everyone concerned, and especially on those connected with the Admiralty, who were the moving spirits in the enterprise.

At the commencement of the war we were as well, if not better, provided with submarines than our enemies, but we had very little scope for their use. Our boats could sail the seas with safety, but penetration into the harbours where our foes lay behind booms and minefields was almost impossible. It was very seldom that a German ship was to be found around our coasts, and then it was generally disguised very effectively. The Germans, on the other hand, could find a target every day, and a great many of their torpedoes got home with fatal effect not only on merchant ships, but also on war vessels. For a time we were almost helpless against this method of attack, and the engineer had a most difficult task set to him. Step by step, our means of defence grew more efficient. We fenced off whole areas of the Channel with nets such as had never been seen or imagined before. We mined in a systematic manner hundreds of square miles of the North Sea; we evolved the motor boat with its single gun, and the skimmer with its single torpedo; we had our decoys and our mystery boats; while overhead the crews of our airships strained their eyes to trace the shadows of the submarines as they glided below the waters of the Channel. Depth bombs were devised and have accounted for dozens of U-boats, of which we have seen nothing but the periscope and sometimes not even that. Listening devices have been perfected until they will pick out the beat of a submarine propeller at a distance measured in miles. So successful have been the efforts of the engineer that lately nothing but the iron discipline of the German Navy could force the half mutinous crews of the submarine to run the gauntlet of the numerous perils that awaited them.

For many years past the efforts of the engineer have found a ready welcome at the Admiralty, and there was little leeway to make up in the Navy. We were certainly short of airships and seaplanes, but a good foundation had been laid and the fleet as a whole was quite equal to our requirements as long as the enemy conformed to the rules of civilised warfare. The experiments that were tried early in the war, in the way of fast, heavily armed cruisers and steam-propelled submarines, showed that it was difficult to improve on existing designs. It was not until the German submarine began to "run amok" among unarmed passenger and merchant vessels, that our naval constructors had to branch out into new directions calling not only for skilful design, but also for bold imagination. As we have said, the engineer confronted and scotched this danger, which for a time seemed the most formidable we had to face. If our enemies had been more diligent students of Admiral Mahon they would not, however, have felt such unbounded confidence in the U-boat. That distinguished writer on naval strategy laid down the principles, which he illustrated by numerous examples, that no nation has ever conquered its antagonists on the sea by the *guerre de chasse*—that is, by striking at his commerce and shirking battle with his fleets. In the Napoleonic wars we lost 10,000 merchant ships, but we won through all the same, and whatever marine developments are in store for us we shall never be crushed as long as we have a fleet which can keep command of the sea. That is no reason, however, why we should not endeavour to minimise our commercial losses as far as possible, and many millions might have been saved if our engineers had been encouraged when the submarine was first introduced, to get out schemes for its destruction other than by gunfire, and we had not placed so much confidence in international law.

We have no space this week to discuss what is going to be the position which the engineer will occupy in the future. As we have seen, he has found an antidote for every carefully prepared appliance of the enemy, and has armed 5,000,000 men with the most exact and efficient weapons ever seen. Even the daily press talks of the late struggle as an engineer's war. Will engineers, in their corporate capacity, be content to be summarily dismissed when the Government has no further need of them, or will they, like the medical men, insist that they constitute an honourable profession which demands terms of recognition and treatment consonant with its usefulness and its dignity? As long as the war lasted patriotism prevented any action which suggested self-seeking in the slightest degree, but when peace is concluded their can be no reason why engineers should not claim and secure the position they have demonstrated to belong to them.

THE DYNAMICAL THEORY OF ELECTRIC ENGINES.

Some day the Kelvin Lecturer of the year, despairing of interesting his audience by comments of sufficient novelty on the work of Kelvin, may have to take up the part of the *advocatus diaboli*. The greatest scientists have had to submit to that fate. In recent treatises we read perhaps more of the baneful influence of Aristotelian dicta than of his wonderful powers of reasoning and observing and of the stimulus his work and methods gave to his age. That later generations grew as harshly intolerant of anything that Aristotle had not taught as they were of anything which they considered contrary to the Bible, was the fault of the Middle Ages and not of the peripatetic philosopher. Yet without the overpowering authority of Aristotle the view that the earth is the stationary centre of our universe would certainly not have survived till the days of Copernicus (1543). Similarly Newton's masterful opposition barred the acceptance of the undulatory theory of light. But many discredited views of Aristotle have been re-established, and the present drift is back toward some corpuscular theory of light, though hardly in Newton's sense. When Lord Kelvin died eleven years ago, most scientists probably felt that, relying upon unsatisfactory experiments, he had unwillingly misled them as to the nature of the Volta effect. Since then opinions have verged round once more to a true Volta effect. There was no occasion for this year's Kelvin lecturer, Mr. Llewelyn B. Atkinson, to plead as *advocatus diaboli*, when he addressed the Institution of Electrical Engineers on November 7. Even the *advocatus diaboli* protested only *pro forma*, moreover, merely to heighten the glory of the Saint whose beatification he seems to contest. Mr. Atkinson's very instructive lecture—a matter for careful study, of course, and not for an abstract—was neither a critique not a eulogy of Kelvin. Choosing "The Dynamical Theory of Electric Engines" as his subject, he took his fellow members back to the middle of the past century and raised a theoretical structure on foundations which Kelvin had laid, but upon which he had not built and which others had overlooked.

The paper on the "Mechanical Values of Distributions of Electricity, Magnetism, and Galvinism," which Professor William Thomson read before the Glasgow Philosophical Society in 1853, was the outcome of researches going back to 1870. Thomson mentioned in that meeting that Grule had made similar suggestions in 1840, and that the general idea had been put forward by Helmholtz in his Conservation of Energy of 1847. But Thomson first indicated how the energies related to electric and magnetic conditions could be calculated. The mechanical value V of the electrification of an insulated conductor, he showed, is half the quotient of the square of the quantity of electricity Q and the capacity of the conductor $c = Q V$ where V is the potential of the charge; thus $W = \frac{1}{2}\Sigma\ (A V)$. To arrive at the mechanical value of magnetism Thomson considered that, when a piece of iron is approached to a magnet, the induced magnetism increases with further approach, and work is done by the attraction; when the magnet is withdrawn again, the induced magnetism first remains constant (owing to the coercive force), and more work is done than on approach, the balance is the mechanical work of the remaining magnetism, $W = \iiint (k) R^2\ dx\ dy\ dz / 8\pi$, where (k) denotes the permeability and R the resultant magnetic force at points $x\ y\ z$. The energy of an electric current can be deduced by imagining that a current is excited in a closed circuit and the electric motive force then stopped. The current will retain energy of the value just given in the magnetic formula except that R^2 now denotes the resultant electro-magnetic force and that (k) falls out. "This expression," Thomson wrote, "is very useful in the dynamical theory of magneto-electric machines and electro-magnetic engines." As neither Thomson nor anybody else has developed a theory of generators and motors on this basis, however, Mr. Atkinson showed how a general theory and classification of electric engines arises from these principles. The interesting point of Thomson's deductions, we should first remark, is that he reduced his results to terms of the heat equivalent, and that he worked in dynamical units, and not in any of the arbitrary units of his contemporaries. He also stated that a term for the energy of motion of something in the wire might have to be added, should it be found that electric inertia existed, that qualification would admit the electron.

In developing Kelvin's views, Mr. Atkinson first kept to Kelvin's arguments. Faraday and Kelvin quite understood that the seat of energy stored in charged conductors lies in the medium filling the space between the conductors. The electrostatic energy may hence be expressed as in the integral formula above with respect to the elements of space, $F^2 K$ being substituted for R^2, where F is the electrostatic force and K the dielectric constant. When the medium is air, which breaks down under a stress of 100 electrostatic units (about 30,000 volts) the maximum energy that can be stored per cubic centimetre is 400 ergs.; in the case of mica (break down pressure 1,000,000 volts) the W amounts to 1.3×10^8 ergs. per cub. cm. or to about 1 ft. lb. per cub. in. When we introduce capacity into the formula in order to allow for the form and distance of the conductors and the nature of the dielectric, the energy may be expressed $W = \frac{1}{2}\Sigma$

$(QV) = \frac{1}{2}\Sigma\, U^2/c = \frac{1}{2}\Sigma\, V^2c$. Mr. Atkinson explained in this connection how a conductor may be charged either by contact or by induction, adopting the energy point of view which is not that of text books. In the formula for the magnetic energy Thomson himself later used H instead of R and μ permeability instead of (k). The energy of a simple circuit system is $W = \frac{1}{2}\, I^2\, L$, and that of two systems a and b $W = \frac{1}{2}\, L_a\, I^2_a + M\, I_a\, I_b + \frac{1}{2}\, L_b\, I^2_b$, where the I are the current intensities, L the coefficients of self-induction and M represents the coefficient of mutual induction. The maximum electromagnetic energy that can be stored in unit space is not limited by any breakdown in the medium, but by the heat generated on the conductor carrying the magnetising current; hence instantaneous high values are obtainable. But the energies stored are not comparatively of large magnitudes. The energy in a piano wire stretched to the breaking point, *e.g.*, would amount to $1{\cdot}28 \times 10^9$ ergs., and by adiabatic compression 54×10^6 ergs. per cub. cm. may be stored in air by a pressure of 300 lb. per sq. in. Yet we must for electromagnetic energy not overlook the importance of the medium and its permeability. For equal magnetic induction ($B = \mu H$) the magnetic energy stored in a volume of iron would only be 1/2000 of that stored in the same volume of air, whilst for equal magnetising forces (at least in the case of small H) the ratio of the energies would be invested, 2000 : 1. As regards the form in which the energy exists in space our knowledge is incomplete; the electrostatic energy has the form of stress involving tension in the direction of a force, and pressure at right angles to it; the magnetic and electromagnetic energies are kinetic, also involving tension (along the line of force) and pressure. When current-carrying conductors are allowed to move, they do work or absorb work, and Kelvin showed already that these movements involve changes in the energy contained in the system. By following up his suggestions Mr. Atkinson arrives at his classification.

Proceeding upon the customary lines Mr. Atkinson discussed I, electric engines converting electric energy into mechanical work (motors) and distinguishes: A, electrostatic engines, on which the forces producing motion are due to the mechanical attraction or repulsion between electrically charged conductors; B, magnetic engines propelled by forces between magnetised bodies; C, electromagnetic engines whose forces are set up by current-carrying conductors. Under A he differentiates between (1) machines in which charged conductors move relatively in a medium of uniform specific inductive capacity, and (2) machines in which relatively fixed conductors move in a field of varying inductive capacity. In both types the conductors may (a) be charged, insulated and then moved (constant quantity of electricity), or (b) be connected to a source of electrification (constant potential). Case (a) corresponds to the piston engine in which steam is admitted behind the piston till the space is filled, the valve closed, and the steam expands until released, the remaining pressure energy being lost. In case (b) steam is admitted throughout the whole stroke at full pressure; the work then done is greater than in (a), but as the steam exhausts at full pressure, the efficiency is lower. The reason is that in (a) the work done in movement is the equivalent of the energy charge, and that an increase in the capacity diminishing the energy of the system corresponds to the work being done, so that the mechanical work is equal to the decreased energy of the system, whilst in (b) the potential being maintained constant, an increase of capacity leads to an increase of the charge and the work is equal to the increased energy of the system. Mr. Atkinson went fully into these cases because they illustrated his dynamical point of view, though electrostatic motors have never been used in any practical way; they might be, he thinks, if other dielectrics were substituted for air.

As regards B—magnetic engines—the point is to find novel means of magnetising and demagnetising iron (other than by currents). The only property so far utilised seems to be that iron loses its magnetism at high temperatures. Practically the problem looks hopeless, and theoretically it is exceedingly complex.

It is to C—the electro-magnetic engine—that Mr. Atkinson devoted his chief attention. Ohm's law is not one of his fundamental considerations. As it only holds steady currents he is entitled to disregard it in his dynamical deductions; but we are not sure whether it is legitimate to regard the "ideal" engine and its conductors to be devoid not only of friction and of current leakage, but also of resistance. Resistance seems to be something very different in nature from friction and leakage. In principle the conceptions may be conformable, however, and Mr. Atkinson, met, at any rate, at a later stage, the objection to his neglecting electric resistance. His chief assumptions are that the current once established by an electromotor force in a freed circuit will remain steady, unless there is an electromotive force acting, and that, with relative movements of two circuits a and b, the electrokinetic moments remain constant, viz., $K_a = L_a\, I_a + M I_b$, and $K_b = L_a\, I_b + M I_a$; thirdly, that of Lenz's law, that the induced currents have such a reduction that their reaction tends to stop the motion producing them. In engines of one circuit and of variable self-induction, he deduces that efficiency is generally low, but a motor with only one coil and a moving iron core might attain the theoretical efficiency 1. With engines of two circuits and variable mutual induction an efficiency may be attained in various ways, several of which might deserve attention. The early closed Pacinottz coil was of high efficiency and was therefore universally adopted; but motors to be run at a large range of speed might be designed on new lines, with brushes connecting each coil to supply for a period. The open or semi-open coil types of generators of Brush-Thomson-Houston and of Immisch have proved successful. Mr. Atkinson suggested motors on those lines.

In Part II, Engines converting Mechanical Work into Electric Energy are dealt with on similar lines, particular attention being again, in the first instance, directed to electrostatic generators, known as electrophorous, frictional and influence machines. We know little about their action; all their efficiencies are deplorably low; a 10-in. plate Holtz machine absorbs something like 25 watts to yield 1 watt, and the ideal efficiency is not very promising, yet their design and cycle of operations might be improved. Finally, Mr. Atkinson made a few suggestions on Combined Generator and Motor Systems. Any transmission of power combines the two processes, but Mr. Atkinson confined his remarks to electrostatic conversions, showing that, to transfer energy from one system to the other, the generator movement should always precede the motor movement.

It may be objected that since electric engineering overshadows other branches of engineering in the perfection and almost theoretical efficiency of some of its machines, the deductions of Mr. Atkinson have merely a theoretical interest. Even if that were so they would be most welcome. Novel points of view always prove fruitful. His expression for the efficiency of electric machines is very similar to the cognate formula for the efficiency of the ideal heat engine, which is expressed by $(t - t_1)/t$, the rates of the difference between the temperatures of taking in and of rejecting heat to the former temperature. The essential difference between the two expressions is, however, that in the heat engine ideal efficiency could only be realised if we could lower the temperature of rejection to absolute zero, when all the molecular movement of heat would cease. In electric engineering we can, Mr. Atkinson argued, theoretically reduce to zero the final steam energy of the electrostatic engine or the motion energy of the electromagnetic engine, and thus realise high efficiencies. He ascribed this difference to the fact that heat energy is directionless, like the waves on the surface of the sea, whilst electric forms of energy have definite directions, like a flowing stream or the tide. We do not quite follow this argument. But the lecture contained many useful suggestions, and we agree that, if a small fraction of the labour and money spent upon the development of the war magneto had been devoted to the improvement of the electrostatic generator, some practical and useful type of new generator might have been constructed.

ALSACE-LORRAINE AND GERMAN INDUSTRY.

It is not to be wondered at that the Germans discuss with much concern the influence the impending severance of Alsace-Lorraine from the German Empire is likely to have upon their industry. As a proof of the importance which Germany attached to the acquisition of these French provinces in 1871, we may mention that some time before the conclusion of peace the German or the Prussian Government despatched a number of mining experts to Alsace-Lorraine in order to investigate the iron ore deposits of the provinces. The result was so encouraging, that it made Germany most desirous of securing them.

Now that the recession of Alsace-Lorraine has been accepted in principle by Germany, the probable consequences of the loss of these areas, so rich in minerals, has become matter of grave consideration. The Germans openly admit that they are not particularly rich in some of the most important raw materials, especially in iron ore and petroleum. As regards the first of these, iron ore, it is admitted that the immense development of the German iron industry during the last four or five decades would have been impossible without the acquisition of the ore deposits of Lorraine in the year 1871. It is not the actual steel production of Alsace-Lorraine which is important, for in 1913 this production only amounted to 2,286,354 tons, against an aggregate for the German Empire of 18,958,819 tons. The importance lies in the fact that the rest of the West German iron industry, more especially that of Rhineland-Westphalia and the Saar district, covers a very important part of its iron ore requirements from the minette deposits of Lorraine. The production of iron ore in Lorraine and Luxemburg (and it must be remembered that the Luxemburg iron industry is closely connected with Lorraine, and if Lorraine is severed from the German Empire, the joint customs arrangement with Luxemburg cannot be maintained) amounted in 1913 to 28,500,000 tons out of a total of 35,900,000 tons for the whole of the German Empire, the contents of iron being respectively 8,150,000 tons and 10,540,000 tons, or 77 per cent. of the total. With the loss of Lorraine the German iron industry will have to depend principally on ores imported from abroad, of which the imports in 1913 amounted to about 14,000,000 tons, with contents of iron amounting to 7,700,000 tons. Although it will be possible after the war to import iron ore from Sweden, Spain, Russia and perhaps even from France, yet apprehensions are expressed that it will be difficult to maintain and develop the German iron industry on such a narrow basis.

The alkali problem also gives cause for much concern in Germany. The country certainly possesses an abundance of alkali deposits and alkali works, apart from the Alsace deposits, enough both for the home requirements and for export. But the world monopoly in potash which Germany formerly possessed, apart from some less valuable deposits in Spain and the United States, will be lost with the Alsace deposits. That means that Germany will lose one of her few economic political weapons. Even if the loss arising from the recovery of the Alsatian deposits may have been exaggerated in certain hostile quarters, it is looked upon as a very serious matter in Germany. The monopoly Germany hitherto has held not only enabled her, in a way, to fix the export or foreign prices and in any case to keep them above the home prices, but it also formed a valuable instrument for bargaining in commercial treaties. The loss of the Alsatian potash works may not mean an end to the German export, but it puts an end to the former independent and profitable export policy. There must result either a price competition or an understanding with the future controllers of the alkali industry of Alsace.

The third commodity with reference to which Alsace-Lorraine plays a part, is petroleum. Before the war Alsace produced about 42 per cent. of the aggregate German output of petroleum, say, some 120,000 tons. The home production, however, is of only limited importance compared with the imports.

Germany tries to find consolation in the thought

that the gain to France from the return of Lorraine will not by any means be as great as will be the loss to Germany. France had never been able to create an iron industry in Lorraine of equal magnitude to that the Germans have fostered, nor will she, think the Germans, be able to maintain it at its present level, partly because France lacks Germany's genius for huge industrial undertakings, and partly because she does not possess adequate home supplies of fuel. France's lack of industrial capacity is illustrated, say the Germans, by the large French family possession of the de Wendel works in German Lorraine, recently compulsorily liquidated. Although this concern owned some of the richest and best iron ore deposits, it remained a long way behind similar large German works in production and plant, and management. The Germans maintain, that the process of production is faulty, that the organisation lacks system, the financing is inadequate and that the management is bad. They comfort themselves with the thought that what French energy and initiative could not attain on German soil, will prove still impossible on French soil. That portion of the minette district which remained in French possession contains more and better ore than the districts ceded to Germany in 1871, yet France has not been able to establish an iron industry which can compare with that of the German Lorraine. France has only smelted a small portion of the iron ore production of Briey and Longwy, large quantities of the ore produced having been exported. This, however, was not solely owing to French lack of enterprise, but more especially perhaps to the shortage of fuel for the iron works, more especially coke. Prior to the present war there was an exchange arrangement between France and Germany, the former country supplying the latter with considerable quantities of Briey ore and in return receiving coke, which was of great use to the French iron industry. Germany now questions, not the ability of England to supply France with the requisite coke, but rather her willingness to do so, inasmuch as she thereby would help an industry which may prove a serious competitor. But perhaps England, so argues the speculative Germans, would rather see the Lorraine iron ore deposits and iron industry in French than in German hands, inasmuch as this will ease the future competition.

That the loss of Lorraine, however, will mean a most serious blow to the German iron industry may be taken for granted and is openly admitted by the Germans.

THE OCCLUSION OF GASES BY METALS.

The subject of the occlusion of gases has grown into one of primary importance. The term covers a multitude of phenomena, all more or less allied with chemical combination, which may be distinguished as surface condensation, adsorption and absorption, diffusion and occlusion proper, but which can hardly be kept separate. Having generally occupied the chemist and physicist, the problems of the occluded gases forced themselves upon the metallurgist, and the development of the incandescenot filaments mounted in vacuum bulbs obliged the electrical engineer to join their study. When, later, electrons and thermoionic currents became realities for the manufacture of X-ray bulbs and radiotelegraphic apparatus, gas occlusion again obtruded itself, and chemists and physicists, frequently in collision of late, once more differed as to the parts played by electrons and by the occluded and residual gases. In the early days gas films had been the main problem. They seemed to adhere to all solids, smooth hard surfaces not less than porous masses of finely divided particles, with a tenacity baffling all attempts of removal, at least by means which the experimental conditions would admit. As to how far the Volta effect depends upon gas films, is still unsettled. That a few metals, such as platinum and palladium absorbed hundred times their own volumes of certain gases, sufficient in fact to act as gas electrodes, in voltaic cells, appears to be a specific property. But metallurgists soon began to understand that the gases retained by most metals might change the properties of those metals as much as impurities like sulphur and phosphorus. In investigating the phenomena it must be borne in mind that we have to deal with occlusion and with liberation of gas; the two may run parallel, and we can hardly study more than equilibrium conditions. The main facts of gas occlusion are undisputed; there is much divergence as to quantitative and qualitative detail, however. What is wanting, in fact, and may remain wanting owing to the intrinsic experimental difficulties, is a method for determining the amounts of gas evolution and of occlusion which will exclude all influences due to the parts of the apparatus not actually under test. The Faraday Society was, therefore, well advised to devote the first meeting of the session to a General Discussion on the Occlusion of Gases by Metals. The discussion was held on Tuesday last, both in the afternoon and evening, in the rooms of the Chemical Society; Sir Robert Hadfield, Bart., F.R.S., the president of the Faraday Society, being in the chair. Eleven papers were presented. We begin our account with Sir Robert Hadfield's comprehensive address, taking then the general physical papers and afterwards the communications chiefly of metallurgical interest.

Sir Robert Hadfield reviewed the history of the occlusion problem since the days of Graham and Bessemer, adding a bibliography which looks complete, though he disclaimed that designation, and drawing attention to the recent detailed summary of the subject and the experiments of Alleman and Darlington.* Graham, it is rather curious, first expelled hydrogen from meteoric iron (1863); Ste. Claire Deville and Troost experimented in the permeability of hot metals to gases, and Graham selected meteoric iron because it had probably travelled through hydrogen in the upper layers of our atmosphere. Bessemer compressed steel in 1856 to get rid of gases. Sir Robert doubted that ferrous alloys occluded as much as 200 volumes of gas, unless in exceptional cases; even that amount would only represent 0.14 per cent. by weight of hydrogen and 2 per cent. of nitrogen, however. Heating nickel wire of high purity in the oxidising and the reducing flames of a Bunsen burner he had not observed any change at temperatures of 1,000 deg. C. and more; but when he heated the wire in an oxidising flame over burning sulphur, it became quite brittle, and that was observed also when the wire was heated to 1,000 deg. over an open coke fire.

Professor H. Le Chatelier, Sir Robert continued, attributed the heterogeneity of steel solely to oxygen; the suggestion was made on the strength of etching experiments with Stead's reagent, and if the experiments should be confirmed, we should have to change our view on the interpretation of macrostructure produced by the copper reagent. According to the late L. P. T. Héroult sound ingots gave off hydrogen, nitrogen and carbon monoxide when placed in a vacuum cylinder, and the percentages of these gases were supposed to depend on the process used, Bessemer, hearth, electric furnace, &c. As a matter of fact, however, the gas volumes varied little with the kind of iron, and the blowholes were the result of the disengagement of carbon monoxide produced during the cooling of the steel. Very useful work on the elimination of unsoundness by silicon and manganese alloys had been done by Euverte, Pourcel and Gautier, of the Terre Noire Works, France. Sir Robert dwelt at length on these researches and referred also to slag enclosures and to forging temperatures. Pure decarbonised iron from the converter (without aluminium) forged at 700 deg. C. and again at 1,200 deg. though it was riddled with blowholes, but would not forge at intermediate temperatures; when 0.2 per cent. of Al were added, the iron would forge at 700 deg., but would crumble at 1,200 deg. One could not generally say, therefore, that aluminium made blown iron forgeable, and the presence of gases might have something to do with the peculiar observations mentioned; the soft steel or ingot iron known as Armco also showed these peculiarities. Sir Robert had proposed the appointment of a committee on the production of steel free from occluded gases, segregation, piping, &c., at the recent meeting of the Iron and Steel Institute. Large masses of steel and of coal, he pointed out, were wasted in the repeated re-meltings of steel, and in view of the scarcity of iron in all countries and the possible introduction of steel railway sleepers (suggested by Sir John Aspinall) in his recent address to the Institution of Civil Engineers) made economy and scientific methods all the more desirable.

In his General Remarks on the Occlusion of Gases, Professor A. W. Porter, F.R.S., distinguished between chemical combination of a gas with a metal, *e.g.*, formation of hydrogen compounds (hydrides) of palladium and the alkali metals; solid solution, alone or together with combination or with surface adsorption; surface condensation without solution, also in the pores; inclusion, *i.e.*, retention of gas bubbles by the viscous mass of molten metal. The occlusion of up to 600 volumes of hydrogen by one volume of palladium had been ascribed by Graham to the formation of the hydride PdH, by Troost and La Hautefeuille to the formation of Pd_2H, whilst Hoitsema and Roozeboom suggested that hydrogen might be retained as monatomic or as diatomic gas; there might also be two phases, liquid and gaseous hydrogen. Holt, Edgar and Firth had distinguished between (*a*) an adsorbed surface layer of hydrogen under high vapour pressure easily removable by evacuation, and (*b*) an absorbed gas which was not uniformly distributed within the metal; as the temperature rose, the pressure of (*b*) increased; the time rate of the solution of hydrogen was not a simple function of the gas concentration. If the hydrogen were liquefied in the pores, the heat set free by the solution should be the same for palladium and for platinum; but it was 4,672 and 6,610 calories respectively (Mond, Ramsay and Shields), whilst the heat of vaporisation of hydrogen was only 123 calories at 252·8 deg. C. (Dewar) for liquid hydrogen; that heat might be much greater, however, for evaporation from a solid surface. As regards the emission of electrons by hot metals, H. A. Wilson had found that the emission from platinum was reduced to 1/250,000 of its value by a preliminary heating of the metal in oxygen or by boiling it in nitric acid; the admission of a little hydrogen, however, had restored the original emission value. Soddy, on the other hand, stopped the emission from a Wehnelt kathode when he absorbed the residual gas by some vaporised metallic calcium. According to O. W. Richardson, however, thermoionic emission was the intrinsic property of the pure metal, and this was supported by Langmuir's recent researches, which also concerned contact potentials (Volta effect) and photo-electric phenomena.

These considerations were further developed by Professor J. W. McBain, of Bristol, in a communication on "Theories of Occlusion, and the Sorption of Iodine by Carbon." The term "sorption" was introduced by Professor McBain in 1909 to comprise both true adsorption or surface condensation and absorption or true solid solution, phenomena which though generally occurring together and not distinguishable except by adequate experiment, yet differed, he pointed out, strongly as to time relation Adsorption was nearly instantaneous; any time lag could be accounted for by the time required for the dissipation of the heat evolved or the comparative inaccessibility of portions of the adsorbing surface. Absorption seemed to follow Fick's diffusion law*; it commenced with a high velocity, which fell off rapidly, and theoretically it required infinite time to obtain equilibrium. Chemical reactions might complicate both types of sorption, and each chemical compound formed had its own decomposition pressure. Absorption necessitated diffusion; measurable diffusion had been observed in charcoal at — 180 deg. C., in palladium at ordinary temperature, in gold and lead at moderate, and in steel at high temperatures; the rise of temperature might at the same time diminish the solubility, however. Adsorption rapidly diminished with rise of temperature and depended upon the surface development, being essentially a surface tension phenomenon influenced sometimes by electro-capillary effects. Condensa-

* *Journal Franklin's Institute*, February, March, April, 1918.

* See ENGINEERING, page 193, August 23, 1918, Article on "The Principles of Diffusion."

tion on any surface separating two homogeneous phases would occur according to Wolfgang Ostwald's extension of Willard Gibbs' law whenever the surface tension, or any other potential energy in the surface, was lessened by the condensation. The quantitative values of the surface tensions of solids were unknown; but some conceptions derived from the atomic theory by Haber, and quite recently by Harkins and by Langmuir, were very helpful.

According to Langmuir every atom within a solid was tied to an equilibrium point in the space lattice and was attached to all neighbouring atoms by primary or secondary valencies, all of chemical character. Thus a crystal would constitute a large molecule held together by purely chemical forces, and the surface atoms would present unbalanced and unsatisfied valencies on their outer sides; surface tension like cohesion might then be ascribed to chemical forces. Gaseous molecules striking the surface were retained and condensed, not reflected; this, as we pointed out in describing the most modern diffusion and condensation pumps of Gaede, as modified by Langmuir and others, is one of Langmuir's characteristic arguments. The molecules thus formed a surface film tending to grow like a continuation of the solid space lattice. But re-evaporation of the gas molecules also went on, and adsorption was the direct consequence of the time lag between condensation and evaporation, being the result of the kinetic equilibrium. As a rule the film had only the depth of one atom or molecule, except when the solid surface was porous and when the gas was a saturated vapour. When in charcoal, or in a tarnished, oxidised metal, the porous surface was immensely magnified, and the film might apparently have a thickness of many molecules if calculated for the apparent external area.

Professor McBain's own experiments to which he then passed were made with solutions, which offer the advantage that the experiments are more easily controlled than with gases. In conjunction with Dr. O. M. C. Davis and Miss A. E. Laing he has for eleven years been observing the sorption by carbon of iodine (dissolved in toluene, benzene, or carbon tetrachloride) in sealed glass tubes kept in the dark; there is no evidence of any chemical reaction. The following figures will give an idea of the results: 2 grammes of charcoal took up iodine from a solution containing 1·2 grammes of iodine in 100 cub. cm. of toluene at the rate of 0·229 gramme per gramme of charcoal in the first 5 minutes, at the rate of 0·237 gramme in the first 15 minutes, of 0·265 gramme in 1 hour, of 0·315 gramme in 1 day, and of 0·509 gramme in 11 years. About two-thirds of the total iodine finally taken up was sorbed in the first 24 hours, and as there was always equilibrium, at least after 24 hours, between the sorbed iodine and the solution, there must be a continuous transference of iodine from the surface to the interior of the carbon. Professor McBain's conclusion is that surface condensation takes place rapidly and reversibly in a short time, and that the subsequent diffusion, extending over months and years, involves more than half of the total sorbed iodine.

We must for the present pass over remarks made by Mr. H. A. Kent concerning the various phenomena accompanying absorption by compact and finely divided substances under different conditions. Speaking from the point of view of the X-ray bulb manufacturer, Dr. R. S. Willows wished for information particularly upon the following points: (1) Is there any advantage in removing the gas from tungsten wires and targets and from copper sheaths before mounting them in the bulb; (2) can the gases usually present be replaced by another gas which is more readily removed during pumping; (3) what is the best method for this removal after mounting, and what is the temperature necessary in each case; (4) under what conditions are the gases which are condensed on the glass envelope most easily and completely removed? The questions are, no doubt, very pertinent; X-ray bulbs will be wanted for many investigations, and high-tension valves, Dr. Willows suggested, will be required for depositing fog, smoke and fumes by means of high-tension continuous currents as well as for radiotelegraphy. All such apparatus depend upon high vacua, high in the modern sense. Dr. Willows' problem (4), he thought himself, might not fall within the ambit of the discussion; but we agree that it is the most difficult, since the conditions for gas removal vary greatly with the nature of the glass and its ability to stand high temperatures without softening and collapsing.

Mr. Cosmo Johns' contribution on "The Properties of Metals as Affected by their Occluded Gases" led the audience over to the metallurgical side of the problems. Dwelling upon the great variety of phenomena and chemical reactions covered by the term of occlusions, he said that some gases were not originally absorbed, but formed during the cooling of the metal; the absorption of CO by iron was greatly affected by the temperature, especially with respect to the critical range. The gases influenced tenacity and ductility of all metals used for constructional purposes far more than was often assumed; much work had been done on pure metals, but little upon occlusion by industrial metals. Koch had quite recently measured the increase in electric resistance and the diminution of the modulus of elasticity and of torsion which palladium wires underwent when saturated with hydrogen. One of the most instructive of these researches was Heyn's investigation of the absorption of hydrogen by copper. Copper was supposed to form a solid solution of hydrogen; but why should that solution differ so much from the gas-free metal? Molten copper (and iron, too) was known to dissolve more hydrogen than solid copper, and a molten mass saturated with hydrogen became supersaturated on freezing. Some of this gas was expelled while the metal was still sufficiently fluid; part of the gas would, however, be entrapped and form microscopic or macroscopic gas enclosures in or between the individual crystals. Such enclosures could hardly explain all the facts observed. They were sometimes absent, and Heyn in his studies of brittleness induced by hydrogen had been unable to discover any change in the microstructure which would account for mechanical weakness. Thus the solid solution theory seemed to fail. If it were rejected, and if we assumed hydrogen to be soluble in the liquid copper (or iron), but not in the solid metal, and remembered that the most commonly-held view of explaining the tenacity of solids—Mr. Johns stated that he meant by solid a crystalline aggregate—postulated the existence of amorphous, non-oriented atoms as an undercooled cement between the crystal grains, a promising method of accounting for the observed facts became available. The intercrystalline undercooled liquid had not suffered the change of state which occurred when a liquid froze; it must contain more hydrogen in solution than the solid metal could carry, and the changes in properties accounting for brittleness occurred at the boundaries of the crystals. The absorption and expulsion of gas would then affect chiefly, if not entirely, the undercooled liquid. That this amorphous matter had a greater solubility for hydrogen than the crystals was certain from the behaviour of the solid and liquid metal after exposure to hydrogen; Mr. Johns suggested that the greater solubility was also the dominant factor in embrittling steel when exposed to hydrogen under certain conditions.

As regards nitrogen, Mr. Cosmo Johns accepted the facts that iron can decompose ammonia and absorb nitrogen being thereby seriously weakened, probably because nitrides were formed. The occurrence of the gases CO_2 and CO in steel he ascribed to reactions between dissolved iron oxide and carbon at the particular temperature when iron oxide, being thrown out of solution as freezing progressed, became concentrated in the mother liquor between the growing crystals and reacted with the carbon which had not suffered the same concentration. The CO and CO_2 were found in a definite ratio, from which that temperature might be deduced. It was doubtful whether these gases were soluble in liquid steel, for CO_2 would oxidise and CO would carburise the steel; if the mixture should prove soluble, it could only be in the particular ratio of the two gases which would be in equilibrium with the molten metal at the particular temperature. Whether soluble or not in molten iron, these gases must be formed by reactions between dissolved iron oxide and carbon and must be evolved between the crystals thus affecting the properties of the metallic mass; if the gases were soluble, they would become concentrated in the intercrystalline matter as in the case of hydrogen. The presence of certain substances, Mr. Johns continued, in solution decreased the surface tension of liquid metals. In the case of steel the tension would only qualitatively be determined; but it fell as the volume of gaseous oxygen compounds in the solid steel rose. The decrease might be ascribed to a greater concentration of the CO and CO_2 in the liquid steel; but he had already stated that the presence of these gases in solid steel (which alone lent itself to accurate determination) was best explained by considering them as reaction products formed during cooling. The decreased surface tension would thus follow from the presence of dissolved iron oxide. In the case of copper the researches of Hofman and others on overpoling showed that the surface tension of liquid copper was reduced as the copper oxide content increased; but it was desirable to conduct further experiments on molten copper with various concentrations of dissolved copper oxide by cooling small samples of the liquid metal under a non-oxidising slag.

These arguments were carried further and specialised in the very interesting paper on "Balanced Reactions in Steel Manufacture" which Mr. Andrew McCance, D.Sc., presented. During the melting period, he stated, the metal was in contact with various gases, oxygen, nitrogen, water vapour, CO, CO_2, and complex reactions were possible. The fact guiding the investigator in his search for the dominant reaction was that, as the average temperature of melting got lower, there was greater oxidation of scrap and consequently more FeO in the slag; a cold-heat slag contained, *e.g.*, 36·3 per cent. FeO and 36·4 SiO_2, and a hot slag 20·8 FeO and 45 SiO_2. Since the surface scale greatly increased with higher temperature, direct oxidation of the iron by the air could not be the main cause of oxide formation. Oxidation by CO_2 was possible according to (1) $Fe + CO_2 = FeO + CO - 2{\cdot}3$ cal., or (2) $3\,Fe + 4\,CO_2 = Fe_3O_4 + 4CO - 1{\cdot}4$ cal. Both were balanced reactions, (1) had been worked out by Baur and Glässner, and the ratio of CO/CO_2 in the gases which were in equilibrium with the Fe and FeO rose from 1·16 at 550 deg. C. to 2·5 at 900 deg. At 1,500 deg. there would be 92·4 per cent. CO and 7·6 per cent. CO_2; if the iron were in contact with more than this percentage of CO_2, it would be oxidised. But the burnt gases in a steel furnace contained very little CO_2, and oxidation was hence possible; the higher the temperature, however, the greater the difference between the gases in contact and the gases in equilibrium; thus the higher the temperature, the greater the oxidation. This conclusion could also be arrived at by Le Chatelier's heat principle. The action of steam on iron was: $3\,Fe + 4H_2O = Fe_3O4 + 4H_2 + 38{\cdot}5$ cal.; the amount of hydrogen decreased, as the temperature was raised.

In order to minimise the scaling and the accumulation of oxide in the slag, one should melt down rapidly and at high temperature and have a low steam content in the burnt gases. It was erroneous to speak of the temperature of the bath as constant because scrap was melting in the bath; there was no equilibrium, and a real temperature control was in fact, needed. The steam in the gases came from the hydrogen in the producer gas, the composition of which was important therefore for the working and the loss of metal by scaling; according to Baraduc-Muller the rate of evolution of hydrogen during solidification was not much greater than the rate after solidification, and if that were so, hydrogen was not likely to be the cause of blowhole formation.

During the boiling the bath was covered by an impure solution of FeO in silicon; any ore and iron oxide added could only act probably after having first been dissolved in the slag. The slag first oxidised Si and Mn; that reaction did not give rise to gas evolution, however. Then carbon was attacked: (3) $FeO + C = CO + Fe$. Though the FeO was derived from the slag, the reaction really took place throughout the metallic mass, and the FeO was hence divided between two solvents, the slag and the steel, subject

to a partition law; if FeO were removed from the steel, more of this ferrous oxide would pass from the slag into the steel. The CO formed dissolved in the steel until the steel was saturated when the excess of CO escaped; that stage marked the commencement of the boil. Tracing the logarithms of carbon content against the time Dr. McCance obtained a curve consisting of two rectilinear branches, the intersection of which indicated the commencement of the boiling; the curves were obtained by determining the carbon percentages of samples. Further considerations showed that lime might replace silica with advantage towards the end of the boil, but not at the beginning, and much depended upon the temperature control. Proceeding, Dr. McCance showed that it was the carbon, not the iron, which reduced the silicon and manganese. The CO in solution in the iron reacted according to (4) $FeO + CO = CO_2 + Fe$ [the formula is No. 7 in the paper]. Baraduc-Muller had found the ratio CO/CO_2 almost constant (about 8·5) in the gas drawn off from an ingot in four periods between casting and solidification, but the ratio decreased when the temperature of working was lowered. That point was important for the formation of blowholes. Gases being much less soluble in the solid than in the liquid metal concentrated in the last portion to solidify. Now at the finishing stage the steel was saturated with CO; on cooling CO_2 increased (equation 4) at the expense of CO, and if the solubility of the steel for CO_2 were exceeded, blowholes formed. Their formation depended both on the quantity of gas and on its variety, and if solid steel had a much greater solubility for CO than for CO_2, all the peculiarities in the relations between these two gases could be explained. As long as there was no reduction of the gases (equation (4), the total volume of gas per gramme of metal remained unaltered by the reduction of the FeO. This was confirmed by the experiments of Boylston, Goerens and Baker. Dr. McCance finally referred to the grave difficulty of the quantitative determination of occluded gas. Two methods had been used; (*a*) extraction of the gas from the heated metal in a vacuum; the objection was that any gases not in equilibrium would react with the steel; the sum of the volumes of CO and CO_2 found would be correct, not their ratio. (*b*) By fusing the sample in a vacuum with tin or antimony which themselves did not contain gases (Goerens); here the carbon in the steel floated to the surface and reacted with the CO_2 according to $CO_2 + C = 2CO$, this reaction varied with the temperature and pressure, yet qualitative deductions could be drawn. We hope to publish Dr. McCance's paper in full in an early issue.

Dr. Thomas Baker, M.Met., F.I.C., gave a summary of some experiments on the "Gases Occluded in Steel" which he had described before the Iron and Steel Institute in 1909 and later. He determined the volumes of the gases and analysed them; we print his paper on page 572 of this issue. One of his specimens was taken from an ingot with blowholes; the second ingot had been rendered sound with the aid of aluminium; the third was a soft steel. The specimens were heated in glazed porcelain tubes; blank experiments were first made with the apparatus, and the blowholes in the unsound specimen were slit open, because Dr. Baker wished to determine the amount of gas occluded in the proper sense. The volumes of gas found were always low, compared to the figures obtained by some other workers; there was not much difference in the behaviour of the three specimens as to the composition of the gases, the hydrogen evolution began first and reached its maximum at 600 deg. C., whilst the CO evolution was strongest at 688 deg.; the soft steel had its maximum hydrogen evolution at 786 deg. and the maximum evolution of CO between the A_2 and A_3 points. Mechanical operations (rolling) squeezed out about half of the gas otherwise found.

(To be continued.)

NOTES.

Steam Boilers in Switzerland.

The Société Suisse de Propriétaires de Chaudières à Vapeur, a Swiss Association for the inspection of steam boilers, having offices in Zurich, has recently issued its forty-ninth annual report, for the year 1917. From this we find that the steam boilers in Switzerland number 5,480, of which 426 (including 228 water-tube boilers) are external furnace boilers, 4,881 are internal furnace boilers, and 173 are ship boilers. Of these latter, 75 are single-ended and 90 double-ended boilers. Of these boilers, 722 have been in service for a maximum of five years, 826 are from 6 to 10 years old, 41 have been built as far back as from 51 years to 55 years ago, 14 as far back as from 56 years to 60 years ago, whilst one is 64 years old and one is 66 years old. The date of construction of 57 boilers could not be determined. The average age of the boilers is 19·2 years. Of the total number of boilers, 4,116, or 75·10 per cent., were built in Switzerland; 997 or 18·18 per cent. were built in Germany; 159, or 2·99 per cent. in France; 147, or 2·68 per cent., in the United Kingdom; 27, or 0·47 pert cent., in Italy; 13, or 0·22 per cent., in Belgium; 4, or 0·06 per cent., in Austria; 2, or 0·03 per cent., in America; whilst the origin of 15, or 0·27 per cent., is unknown. The greater number of the boilers—1,614, or 29·45 per cent.—have a working pressure of from 6 to 7·5 atmospheres, followed by 1,546, or 28·20 per cent., having a working pressure of from 8 atmospheres to 10·5 atmospheres; 8 boilers, or 0·15 per cent., have a working pressure of 20 atmospheres; and 4, or 0·07 per cent., a working pressure of 50 atmospheres. The classification of the boilers according to their heating surface is an extensive one and can be quoted only very briefly. The largest number of stationary boilers—896, or 16·89 per cent.—have a heating surface of from 6 sq. m. to 10 sq. m. (64·58 sq. ft. to 107·64 sq. ft.); 14, or 0·26 per cent., have a heating surface of from 201 sq. m. to 220 sq. m. (2,163 sq. ft. to 2,368 sq. ft.); 83, or 1·57 per cent., a heating surface of from 221 sq. m. to 300 sq. m. (2,378 sq. ft. to 3,229 sq. ft.); 20, or 0·38 per cent., a heating surface of from 301 sq. m. to 350 sq. m. (3,240 sq. ft. to 3,767 sq. ft.); and 3, or 0·06 per cent., a heating surface exceeding the latter figure. Of the ships' boilers, the largest number, 40, or 23·6 per cent., have a heating surface of from 61 sq. m. to 80 sq. m. (656·62 sq. ft. to 861·14 sq. ft.). There are 2 boilers, or 1·2 per cent., having heating surface of 170 sq. m. (1,829 sq. ft.); and 1, the largest, having a heating surface of 184 sq. m. (1,980 sq. ft.). In the course of the year the Association carried out 317 calorimetric tests on Sarre and Ruhr coal, Belgian coal, briquettes, mixtures of coal and briquettes, of lignite and briquettes, peat, wood, &c. Switzerland being badly situated from the point of view of coal supplies, careful attention was also given to the best means of utilising to the full the fuel obtainable and of recovering waste heat.

Higher Education in the United Kingdom.

Some striking statistics as to the provision made in different countries for higher education are set forth in a pamphlet recently issued by the British Science Guild. It is pointed out here that the total income of the universities of the United States is about 20,000,000*l*., the corresponding figure for the United Kingdom being about 2,000,000*l*., and for Germany 18,000,000*l*. Here we have 5,000 full-time students of science and technology, whilst the United States have 34,000 and Germany 17,000. The University of Berlin alone receives from State funds a grant nearly equal to the total Parliamentary grants to universities and colleges in England and Wales. It may further be pointed out that 80 per cent. of the total income of the German universities was derived from State grants, the corresponding figure here being 34 per cent. This generous subvention from national funds has made the financial position of the German universities very secure, but has not been, it may be observed, without its drawbacks. These State subventions have meant State control, and appointments have been confined to those whose political opinions were considered satisfactory to the ruling powers. It has frequ ntly been asserted that the Franco-Prussian war was won in the class rooms of the German universities. Whether this be true or not, it is unquestionable that the spirit which has led to the world catastrophe of the past five years was certainly fostered there, and in any measures taken for further State aid to our own universities and colleges it will be a matter of prime importance to ensure the fullest freedom to each, in the orientation of studies and in professorial appointments. Some important first steps towards a more adequate endowment of science in this country have already been made. The Department of Scientific and Industrial Research has been established with a block grant of 1,000,000*l*., whilst 3,000,000*l*. have been paid over to the Development fund and other grants have been made for promoting medical research. We still remain, however, very much behind America in these respects. The Carnegie Institution has an endowment of 4,400,000*l*. and the Rockefeller Institute at New York, founded specially to promote research in the prevention and treatment of disease, has been endowed with 3,000,000*l*. These two institutions are the outcome of the public spirit of private benefactors who have been largely responsible for the very ample endowments of higher education in America generally. In a past generation, when rates of profits here ruled much higher than in the recent years, a similar spirit was in evidence in Britain, as is instanced by the foundation of the Owens College at Manchester and the Mason College at Birmingham. The large benefactions made by individuals in the States have been very liberally supplemented by public grants. Five States of the Union, four of which have populations of under 3,000,000 each, gave grants to universities which, together, exceed the total Parliamentary grants to colleges in England and Wales. Fortunately the scientific standing of a nation is not directly proportionate to the liberality with which research is endowed, or Great Britain would occupy a very minor position. In this connection the report of the British Science Guild is, to say the least, misleading. It asserts that when the Duke of Devonshire's Committee reported more than forty years ago, scientific research was all but dead in England. With men like Darwin, Maxwell and Kelvin at their prime such a statement is ridiculous and tends to weaken the force of the appeal made for increased recognition of the value of science. The committee apparently overrate the importance of contributions to scientific data which can often be made by mere hodmen of science as compared with contributions to scientific thought for which but a few exceptional men have the necessary intellectual endowments.

Higher Prices for Electric Energy in Berlin.—Owing to the increase in wages and the price of raw materials and of coal, the charge for electric current in Berlin has been raised by an additional 25 per cent., making the total increase 50 per cent. The additional charge according to area is also being raised.

Belfast's War-Time Work.—The following figures indicate the growth of Belfast's shipbuilding and repairing work during the war:—

Year.	Merchant Ships. Built.	Tonnage.	Vessels Repaired.
1915 ...	6	26,000	140
1916 ...	2	14,000	271
1917 ...	17	145,000	207
1918 (ten months)	17	150,000	167

The number of vessels arriving in Belfast Harbour on Government business mainly connected with the building and repair of ships, which in 1916 was 818, for the ten months of this year had grown to 2,037.

A Large Timber Raft.—Considerable sensation has been caused by a new venture in the way of timber transport, by means of a huge raft or float of timber, now on its way from Haparanda to Copenhagen. It is 112 m. (367 ft.) long and 16 m. (52 ft. 6 in.) broad, and although towed by two powerful tugs, it is only travelling at a speed of 3½ knots. It is expected that this venture may lead to a regular mode of transport. The raft is composed of 2,100 standards of cut timber, planks and boards of different dimensions. The timber is laid alternately lengthwise and crosswise. The whole constitutes a heavy hull, pointed fore and aft. The timber is kept together by heavy steel ropes which have cost some 60,000 kronen. Very likely such substantial bindings may not prove necessary owing to the increased adhesion of timber when wet. The raft has a rudder operated by a winch placed under cover, where the crew, consisting of seven men, have their quarters. The rope between the raft and the tugs is 100 m. (328 ft.) long. The timber may not benefit by this long immersion in water, but experience alone can show to what extent this is the case. It took two months and a half to build a raft, called the "Refanut," but normal building time for the future is put at six weeks, and next year it is proposed to build 40 such "Refanuts."

INDUSTRIAL NOTES.

The Minister of Munitions has appointed a Demobilisation Board to deal with all measures affecting the demobilisation of munitions works, and the liquidation of contracts, apart from the questions assigned to the Resettlement Board under the Minister of Labour.

The Board will consist of the following members: Sir James Stevenson, Bart., chairman; Mr. H. H. Piggott, C.B.E., secretary; Sir Stephenson Kent, K.C.B., labour; Mr. W. T. Layton, C.B.E., priority; Sir Arthur Duckham, K.C.B., liquidation of contracts (aircraft and engines); Sir Gilbert Garnsey, K.B.E., liquidation of contracts (all other contracts); Mr. Alexander Walker, disposal and sale of stores; Sir Keith Price, disposal of factories, &c. Major-General the Hon. Sir F. R. Bingham, K.C.M.G., military services.

The secretary of the Ministry (Sir W. Graham Greene, K.C.B.), the assistant secretary (Mr. J. E. Masterton Smith, C.B.) and the chairman of the Finance Committee will be *ex-officio* members of the Board.

The Board will be assisted by the following expert advisers: Mr. S. Dannreuther, C.B.; Sir Philip Henriques, K.B.E.; Sir John Mann, K.B.E.; Mr. W. J. Larke, O.B.E.

Financial Departmental representatives will also be attached to members of the Board.

The Board will continue to be advised on labour matters by the Resettlement Board under Sir Stephenson Kent, K.C.B., who remains a member of the Munitions Council.

At the twenty-second ordinary general meeting of the Trafford Park Estates, Ltd., held in Manchester last week, the chairman, Mr. Marshall Stevens, stated that Trafford Park was mobilised for peace. Six hundred acres were disposed of to traders determined to solve the great problem set them to maintain our renown in peace as in war. Five hundred other acres, with all the attendant exceptional shipping, railway and other facilities, were available to other traders desirous of facing the coming intensive world trade competition under the new conditions. What the country had to consider seriously, when the demobilisation of the army came, was the mobilisation of trade, and the first thing for the nation to set about was to regain some of the liberty which it had willingly given up for the purpose of the war, but which was an essential of prosperous and progressive peace. Shipbuilders, manufacturers, merchants, and bankers wanted to be relieved from Government control. As an illustration, the speaker stated that Trafford Park Estates as a company depended, as it was a land company, upon the enterprise of corporate bodies or individuals who desired to establish or extend industrial works in connection with railways in close proximity to the ship canal and docks, and within easy reach of the labour market. For such adventures, capital was essential. During four years, industry had been starved of capital; no company without the permission of the Treasury Committee could raise a penny from the public. But when trade is mobilised, when it is freed from the strict Government control, capital will be available—although scarce for a time—and the nation may then look for a revival of its various enterprises. Dealing with labour, the speaker added that there were 5,000,000 men waiting for the disbandment of the army, to be drafted into productive civil employment. At home, there were 2,000,000 men and 750,000 women employed on munitions; the greater part of their work would soon cease. Employment had to be found for 7,000,000 men, and the capital required for this huge remobilisation of labour could only be forthcoming slowly. This was a problem which was more difficult of solution than the creation of an army. Still, although there were these economic dangers ahead, that we had done fairly well in the bad past was an augury that we might continue to progress and prosper in the not very promising future.

The reconstruction problems which now faced the nation were dealt with exhaustively by Dr. Addison, Minister of Reconstruction, speaking in Parliament last Tuesday. Dr. Addison stated that we had to aim at the restoration of our trade and industry as rapidly as possible. If we were to pay for the war, we had to aim at better methods of production, better conditions of life and making a better use of all our resources. We had to recognise the danger that might arise in time of peace from bureaucratic methods. We could not seek to promote the rapid restoration of industry by particular State interference.

He had asked the Ministry of Munitions several months ago to prepare a report on the state of employment in the metal and chemical trades, and it appeared that 70 per cent. of the men and 40 per cent. of the women were still engaged on work of a kind for which there would be a civilian demand after the war. That made the problem much easier. In round figures, there would be about 1,000,000 people who would require to change their occupation with the cessation of war manufactures. What the authorities had to look to was to restore the basic industries of the country which had been shut down and which were capable of absorbing the great proportion of this labour.

Besides this 1,000,000 people, there would be the whole of the demobilised forces, between 4,000,000 and 5,000,000, to deal with. The first thing done when the armistice was practically certain was to arrange with the War Office for the withdrawal of what might be called the "demobilisers" from the army into the reserve at home; these were the people who were to assist in the process of demobilisation, to start the exchanges and other work. It was clear, however, that whatever they did, an interval of unemployment would have to be provided for. He hoped and believed that interval would be a small one.

Dr. Addison then outlined the scheme of out-of-work donation for ex-service men and civilian workers, and gave the broad lines upon which demobilisation would be carried out, adding that he was going very shortly to issue a pamphlet setting out the whole scheme.

With reference to the disposal of the existing war stores, it had been decided that one responsible authority would be appointed. The average value of these stores was estimated at about 500,000,000*l.*, but he hoped that a higher sum than this would be realised. The formation of a Ministry of Supply, to replace substantially the present Ministry of Munitions, had been accepted in principle to act as the central authority. In regard to the available stocks of materials, Dr. Addison stated that there had been a great increase in our capacity for the utilisation of home iron ore, and arrangements were being made by the Shipping Controller which would render it possible to import as large a quantity of foreign ore as was imported prior to the war. It was proposed to release iron and steel forthwith. The difficulties which might arise, owing to the fact that through the exigencies of war the price of steel now stood at an artificial level, had not been overlooked, and it was intended to continue Orders fixing for a period a maximum price for steel, though this might involve continuing some measure of Government assistance for that period. There was a sufficient supply of other metals available to render it possible to release some from control now, and nearly all the rest within six months. Dr. Addison was convinced, after a close survey of the position, that we shall be able to meet the demands which reconstruction will make on our resources.

Last Wednesday, the Prime Minister addressed, at Caxton Hall, a meeting of representatives of employers' associations and trade unions covering the principal industries of the country. He stated that the Government desired to receive the advice and assistance of the above-mentioned bodies with regard to the course to be followed "(*a*) To make provision for carrying out pledges which were given by the Government to the trade unions in March, 1915, at the time when the unions were requested to relax, during the period of the war, certain trade union practices and customs; and (*b*) To provide for the position which is now arising in connection with wages, owing to the fact that, with the change over from munitions work to private work, the rates of wages which have been fixed by awards and orders under the Munitions of War Act will cease to have effect."

Mr. Lloyd George added that the Government wished it to be fully understood that they intended that the pledges given in 1915 would be carried out. The matter should be considered at once by the employers and workpeople sitting together to determine in what way they could deal with it, having regard to the enormous progress made in industry during the war and the knowledge and experience gained as a result of the changes made in industry also during the war.

In regard to wages, he explained that the policy of the Government, with, he hoped the general assent of the employers' and workpeople's associations, was to provide that during the immediate transition period the present level of wages, due as it was to the high cost of living, should be maintained for a period of six months, unless altered by agreement between the parties or by reference to an independent tribunal.

Mr. G. N. Barnes, the Minister of Labour, explained in detail the Government's proposals, and the proceedings were then adjourned so that the representatives of the employers and workpeople might meet to consider the Government's statements.

Modification in Steel Prices.—The Minister of Munitions has given notice of modifications in the prices and provisions relating to (*a*) steel slabs, plates, strips and pieces cut from plates suitable for re-rolling, and (*b*) steel plates, sheets and black plate, all open annealed, produced in sheet mills.

THE CEMENT INDUSTRY.

There has been a good deal of discussion in Germany as to the fixing of the price-level within the cement industry, and in support of the manufacturer's view, that the present quotations by no means are excessive, particulars have been compiled showing the results of the last few years' working as far as 60 different cement works are concerned. Of these 60 works, 14 paid no dividend at all for the year 1917, 8 works paid from 1 per cent. to 5 per cent., 32 works paid from 6 per cent. to 10 per cent., and 6 works from 11 per cent. to 15 per cent.

The average dividends for the last seven years of the above 60 works were as follow: 1911, 4·6 per cent.; 1912, 6·2 per cent.; 1913, 7·9 per cent.; 1914, 2·88 per cent. 1915, 1·32 per cent.; 1916, 1·04 per cent.; and 1917, 6·75 per cent.

It will appear from this, that last year, which some people hold has been almost unduly lucrative, does not come up to the last peace year, and that the three years of the war, 1915, 1916 and 1917, with an average dividend of 3·33 per cent., are a long way behind the last three peace years, 1911, 1912 and 1913, with their average dividend of 6 per cent.

Compared with Denmark and Sweden, Norway, so far, has been behindhand in the matter of the cement industry, having only three factories, of which one is barely ready, against eight in Denmark and seven in Sweden, with an annual production of respectively 3,500,000 barrels and 3,000,000 barrels. The three Norwegian factories are all in the southern part of the country, but a new factory is now being built in the north, at Frysfjord, for an annual production of 300,000 barrels; that a cement factory is needed will appear from the fact, that the nearest factory at present is about 1,500 km. distant.

The United States production of cement exceeds the aggregate of the production in all the other countries, and reached last year the record figure of 94,000,000 barrels. The latest available figures for the other countries are as follows: Germany, 30,000,000 barrels; England, 17,000,000 barrels; and France, 8,000,000 barrels. The growth of the American cement industry has been exceedingly rapid, from a production of 42,000 barrels in 1880, to 335,000 barrels in 1890, 8,500,000 barrels in 1900 and 68,200,000 barrels in 1910. The value of the production rose from 126,000 dols. in 1880 to 101,000,000 dols. in 1917. The factories are distributed all over the States and almost the entire production is consumed within the country, the exports during 1917, in value, only amounting to about 4,000,000 dols.

Prices for Metallurgical Coke.—The Minister of Munitions has given notice of certain additional maximum prices for foundry coke and steel melting coke (Sheffield district). The maximum prices do not apply to any sale or purchase under a contract in writing entered into prior to July 1 at a price not contravening that permitted up to that date.

Electricity Supply Order.—The Minister of Munitions has issued an Order dated November 8 providing that no person may, without a permit, supply, connect, or use any electricity in any building not so connected at the date of the Order. In certain cases, however, coming within the scope of the Household Fuel and Lighting Order 1918 or the Household Fuel and Lighting (Scotland) Order, 1918, where the previous assent of the Local Fuel Overseer is required and has been obtained to any fitting equipment or supply, no permit is required. The permission required by the Order is in addition to and not in lieu of the usual priority certificates and permit reference number. All applications in reference to the Order should be addressed to the Director of Electric Power Supply, Ministry of Munitions, 8, Northumberland Avenue, W.C. 2.

The Rhenish-Westphalian Industry and the German Shipyards.—Some of the leading concerns within the Rhenish-Westphalian iron and coal industry have during the last year or two endeavoured, and in some cases have succeeded in getting an interest in the North German shipbuilding and shipping undertakings. This movement is not altogether viewed with favour by the latter concerns; some of the shipping companies on the North Sea have recently altered their statutes for the purpose of insisting upon certain local qualifications as regards the members of their boards. The Flensburg shipyard, however, has taken a step in exactly the opposite direction, inasmuch as the company's statutes have been worded for the purpose of admitting two of Herr August Thyssen's representatives to the board. Thyssen had already, some time ago, secured a number of shares in the Flensburg yard, and this is the second shipbuilding concern in which Thyssen has acquired a material interest, the first being the Vulkan yard in Bremen. He has thus obtained an influence over the shipbuilding industry both on the Baltic and the North Sea and acquired good customers for many of his products, at the same time standing a better chance of obtaining cheap tonnage. Besides Thyssen, the Gutehoffnungs Hütte, with the Hamburg-America Steamer Company and the Allgemeine Elektricitäts Gesellschaft, is materially interested in the large new German shipyard, now in course of construction, at Finkenwärder, near Hamburg. The Stumm Brothers' concern is interested in the Frerichs establishment at Einswarden, the capital of which has recently been increased. Of older date are the Krupp firm's possession of the Germania yard, Kiel, and the German Luxemburg Company's control of the Nordsee establishment at Emden.

PROBLEMS OF RECONSTRUCTION.

The following statement with regard to advisory bodies, other than reporting committees, appointed by the Minister of Reconstruction, was issued on Tuesday as a Parliamentary paper :—

The Minister of Reconstruction has appointed the following bodies, other than committees required to report on specific terms of reference, to advise him on different aspects of the various problems which come before him :—

1.—The Advisory Council.

The Advisory Council consists of a panel of men and women of mature experience and distinction in affairs, from whom the Minister of Reconstruction can obtain practical and competent advice on any questions of special difficulty or complexity that may arise in connection with the work of the Ministry. For working purposes the council is divided into five sections, each under the direction of a chairman and vice-chairman selected from the members of the council. The chairmen and vice-chairmen of the different sections of the Advisory Council meet, as a rule, once a week, to advise the Ministry informally on any points of difficulty that may arise in the daily work of the department, and to suggest convenient methods of machinery for approaching questions of great complexity and importance. An informal committee of women members of the council, under the presidency of Lady Emmott, will also meet regularly to give the Ministry similar advice in connection with questions affecting the position of women. The council is at present constituted as shown below, but additional members will be appointed from time to time, as may be necessary, in connection with further developments of the work of the council and of the Ministry as a whole.

Section I. (Finance, Transport and Common Services.)—Sir Charles Metcalfe, Bart. (who has acted as chairman in the absence of Sir H. Babington-Smith, K.C.B.), Sir Clarendon Hyde (vice-chairman), the Hon. Herbert Gibbs (financial chairman), Mr. E. Husey (financial vice-chairman), Sir Alfred Booth, Bart., the Hon. Robert Brand, C.M.G., Sir E. Tootal Broadhurst, Mr. Vernon Hartshorn, O.B.E., Mr. W. L. Hichens, Mr. H. J. Mackinder, M.P., Sir Adam Nimmo, K.B.E., Major the Hon. George Peel, M.P., Sir Alexander Roger, Mr. Ernest E. Spicer, the Right Hon. J. H. Thomas, M.P., Sir W. Rowan Thomson, K.B.E., and Mr. Arthur Whitworth.

Section II. (Production and Commercial Organisation.)—Sir Henry Birchenough, K.C.M.G. (chairman), Mr. E. Bevin (vice-chairman), Mr. J. P. Boland, M.P., Sir E. Tootal Broadhurst, Mr. H. S. Clough, Sir Charles Fielding, K.B.E., Mr. W. T. Green, Mr. J. W. Hope, C.B.E., Mr. W. H. Hutchinson, Sir Clarendon Hyde, Mr. H. J. Mackinder, M.P., Mr. J. J. Mallon, Sir Alexander Roger, and Mr. W. H. Watkins.

Section III. (Labour and Industrial Organisation.)—The Right Hon. J. H. Thomas, M.P. (chairman), Mr. W. L. Hichens (vice-chairman), Mrs. E. Barton, Mr. E. Bevin, Sir H. Birchenough, K.C.M.G., Mrs. Butler, Mr. H. S. Clough, Mr. J. F. Duncan, Major-General Sir P. Girouard, K.C.M.G., the Right Hon. Lord Gorell, Mr. Vernon Hartshorn, O.B.E., Mr. J. W. Hope, C.B.E., Mr. W. H. Hutchinson, Mr. C. A. McCurdy, M.P., Mr. J. J. Mallon, Sir Thomas Munro, Sir Adam Nimmo, K.B.E., Mr. Edwin Orde, Sir H. B. Rowell, K.B.E., Mr. R. H. Tawney, Miss G. Tuckwell, and Mr. W. H. Watkins.

Section IV. (Rural Development, including Agriculture)—Mr. Leslie Scott, K.C., M.P. (chairman), Right Hon. Henry Hobhouse, P.C. (vice-chairman), Mr. C. R. W. Adeane, C.B. Mrs. E. Barton, Right Hon. C. W. Bowerman, M.P., Mr. G. Dallas, Mr. J. F. Duncan, Lady Emmott, Sir Charles Fielding, K.B.E., Sir Richard Glazebrook, K.C.B., F.R.S., Mr. Hugh A. Law, M.P., Mr. T. Lundon, Mr. George Nicholls, Major Hugh Pritchard, Major-General A. E. Sandbach, C.B., D.S.O., Hon. E. G. Strutt, Miss G. Tuckwell, Mrs. Roland Wilkins, Mr. David Wilson, and Professor T. B. Wood, C.B.E.

Section V. (Social Development, including Education, Health, Housing.)—Mr. Arthur A. Allen, M.P. (chairman), Lady Emmott (vice-chairman), Mrs. E. Barton, Right Hon. C. W. Bowerman, M.P., Sir Richard Glazebrook, K.C.B., F.R.S., the Right Hon. Lord Gorell, and Miss G. Tuckwell.

Women's Advisory Committee of the Council.—Lady Emmott (chairman), Lady Birchenough, Miss Beatrice Chamberlain, Mrs. Deane Streatfeild, Miss Harris, Miss Susan Lawrence, Dr. Marion Phillips, Mrs. Pember Reeves, Lady Rhondda, Miss Symons and Miss M. J. Tuke.

Advisory Council on the Disposal of Surplus Government Property.

This Council has been appointed "To reconsider and advise, under the direction of the Minister of Reconstruction, as to the manner in which all stores, land and other property (except shipping and Government factories), under the control of Government Departments, being property acquired for the purposes of the present war, and no longer required for the purposes of the departments under the control of which it is, shall be dealt with, whether by the transfer thereof to some other department, or by the sale or disposal thereof to other persons." It consists of the following members, together with representatives of the departments concerned :—

The Most Hon. the Marquess of Salisbury, K.G., G.C.V.O., C.B. (chairman), Sir Howard Frank, K.C.B. (vice-chairman), the Right Hon. W. Adamson, M.P., Mr. G. Lowes Dickinson, Mr. Philip Hanson, C.B., Sir R. Sothern Holland, Bart., Mr. W. Lander, Sir Maurice Levy, Bart., M.P., Captain Sir Beville Stanier, Bart., M.P., and Sir John E. Thornycroft, K.B.E.

Engineering Trades (New Industries) Committee.

This committee was appointed "to compile a list of the articles suitable for manufacture by those with engineering trade, experience, or plant, which were either not made in the United Kingdom before the war but were imported, or were made in the United Kingdom in small or insufficient quantities and for which there is likely to be a considerable demand after the war, classified as to whether they are capable of being made by (1) women, (2) men and women, (3) skilled men; and setting out the industries to which such new manufactures would most suitably be attached; and to make recommendations : (a) On the establishment and development of such industries by the transfer of labour, machines and otherwise : (b) as to how such transfer could be made, and what organisation would be requisite for the purpose, with due regard to securing the co-operation of labour.

The members of the main committee, together with the sub-committees which have been appointed to deal with particular industries, are as follow :—

The Hon. H. D. McLaren, M.P., C.B.E. (chairman), Mr. Charles Bennion, Sir George Bullough, Bart., Mr. F. H. Crittall, Mr. R. Dumas, Sir John Griffith, M.Inst.C.E., Mr. W. B. Lang, Mr. Charles A. Lister, C.B.E., Mr. P. J. Pybus, C.B.E., Mr. G. H. Sankey, Sir Percy Stothert, K.B.E., Mr. John Taylor, Mr. William Taylor, Mr. William Thom, Sir W. Rowan Thomson, K.B.E., and Mr. H. C. B. Underdown.

The Branch Committees are on Wire Machinery; Printing Machinery; Printers' General Machinery; Paper-making Machinery; Leather Manufacturing Machinery; Textile Machinery (Manchester); Textile Machinery (Nottingham); Machine Tools; Agricultural Machinery; Aircraft; Holloware, Sheet Metal, and Pressed Work; Electrical Apparatus; Scientific Instruments; Miscellaneous Machinery; Motor Industry; Labour Panel.

Supply of Raw Materials After the War.

In this connection the Minister of Reconstruction is being advised by committees to whom, for their general guidance, the following terms of reference have been given :—

1. To consider and report upon the nature and amount of the supplies of materials and foodstuffs which, in their opinion, will be required by the United Kingdom during the period which will elapse between the termination of the war and the restoration of a normal condition of trade, and the steps which should be taken to procure those supplies, having regard to :—

(a) The probable requirements of India, the Dominions and Crown Colonies for such supplies at the close of hostilities.

(b) The probable requirements of belligerents and neutrals for such supplies at the close of hostilities.

(c) The sources from which, and the conditions under which, such supplies can be obtained and transported, and, in particular, the extent to which they might be obtained from the United Kingdom or within the Empire, or from Allied or neutral countries.

2. To consider also whether any measure of control will require to be exercised, and the extent and character of such control.

The following are the individual committees :—Aluminium; Antimony; Copper; Lead; Nickel; Spelter; Tin; Ferro-Alloys; Asbestos; Hides and Skins.

Building Materials.

A special committee has been appointed to advise on the important questions connected with the supply of building materials. The War Cabinet recently set up a Cabinet Committee to deal with post-war priority questions and a standing Council on Post-War Priority, composed of representatives of employers and workpeople in various industries, is now at work.

GERMAN STEEL INDUSTRY WAR PROFITS.

The Hoesch Iron and Steel Works, Dortmund, has declared a dividend for last year of 24 per cent., in addition to an extra dividend of 15 per cent. The company has renewed its request for permission to increase its capital by 12,000,000 marks, which has become necessary by the purchase of the Fürst Leopold concern, for which 22,000,000 marks have to be paid in cash. Last year's production shows a material increase compared with that of the previous year, the value of products despatched from the iron works and rolling mills amounting to 152,540,000 marks, against 109,150,000 marks for the previous year. With regard to the future, the continually rising cost of production had not been followed by any rise in prices, except for coal, which was of minor importance, as the company itself used most of its production of coal.

The Bismarck Hütte again declares a dividend of 30 per cent., but for last year the capital entitled to dividend is 22,000,000 marks, against 16,000,000 marks the previous year. The gross profits amounted to 20,170,746 marks, against 16,994,214 marks for the previous year,, the available surplus for the two years being respectively 7,471,960 marks and 5,423,126 marks. Writings-off, &c., amounted to 11,544,756 marks. Through the arrangement with the Westphalian Steel Works, the company became possessed of more than three-fourths of the portions of the Neue Haardt iron ore mines at Weidenau, Siegen. During the year the company's holdings of war loan bonds had increased by 14,000,000 marks, and now amounted to 33,000,000 marks.

The Cast Steel Company Witten, has again declared a dividend of 27 per cent., although the net profit receded from 6,031,353 marks for the previous year to 5,413,271 marks. Material sums were devoted to welfare institutions of different kinds. The report draws attention to the increasing cost of production, whilst the maximum prices remain unaltered.

The Trier Rolling Mill has declared a dividend of 18 per cent. for last year, against 16 per cent. for the previous year, the net profits amounting to 1,626,964 marks, against 931,919 marks for the previous year. The works were fully employed.

The Annener Cast Steel Works again pay a dividend of 25 per cent.; the production showed a substantial increase, but the profits were not quite up to those of the preceding year; prospects were considered satisfactory.

The Lothringen Iron Works and Mining Company, Hildingen, pays a dividend of 12 per cent. for last year. The report said nothing definite concerning the prospects for the current year. The company's Kneutinger iron works certainly lay in the danger zone, but, so far, no serious harm has been done. The company's principal works are located at Troisdorf, in the Ruhr district, and at Düsseldorf, the first-mentioned works standing booked only at 39,000,000 marks, or about 25 per cent. of this large company's capital; the mines alone exceeded in value the share capital, in addition to which there were large "still" reserves. The reconstruction for peace work was in operation at all the works, and on the consummation of peace, work could be continued without any difficulty.

BOOKS RECEIVED.

The Mineral Industries of the United States : Petroleum : A Resource Interpretation. By Chester G. Gilbert and Joseph E. Pogue. Washington : Government Printing Office.

Technology. The Journal of the Manchester Municipal College of Technology. A Record of Investigations undertaken by Members of the College. Vol. IX. Manchester :

The Life and Letters of Joseph Black, M.D. By Sir William Ramsay, K.C.B., F.R.S. *With an introduction dealing with the Life and Work* of Sir William Ramsay. By F. G. Donnan, F.R.S. London : Constable and Co., Limited. [Price 6s. 6d. net.]

Department of the Interior—Canada. Water Resources Paper No. 20. *Report on the Interests Dependent on Winnipeg River Power with Special Reference to the Capital Invested and the Labour Employed.* By H. E. M. Kensit, M.Am.Inst.E.E. Ottawa : Published by authority of the Minister of the Interior.

Liquid Steel, its Manufacture and Cost. By David Carnegie, F.R.S.E., M.Inst.C.E., M.I.Mech.E., assisted by Sidney C. Gladwyn. Second edition. London : Longmans, Green and Co. [Price 30s. net.]

Canada Department of Mines. Annual Report on the Mineral Production of Canada during the Calendar Year 1916. By John McLeish, B.A., Chief of the Division of Mineral Resources and Statistics. Ottawa : Government Printing Bureau.

Mathematical Tables and Formulæ. By P. Abbott, B.A. London : Longmans, Green and Co. [Price 2s. net.

University of Illinois Bulletin No. 104. *Tests to Determine the Rigidity of Riveted Joints of Steel Structures.* By Wilbur M. Wilson and Herbert T. Moore, Urbana : University of Illinois ; London ; Chapman and Hall, Limited. [Price 25 cents.]

United States Bureau of Mines. Technical Paper No. 190. *Methane Accumulations from Interrupted Ventilation with Special Reference to Coal Mines in Illinois and Indiana.* By Howard I. Smith and Robert J. Hamon. [Price 15 cents.] No. 195. *The Tars Distilled from Bituminous Coal in Hand-Fired Furnaces.* By S. H. Katz. [Price 5 cents.] Washington : Government Printing Office.

United States Bureau of Mines. Bulletin No. 123. *Analyses of Mine and Car Samples of Coal Collected in the Fiscal Years* 1913 to 1916. By Arno C. Fieldner, Howard I. Smith, J. W. Paul and Samuel Sanford. Washington : Government Printing Office. [Price 50 cents.]

The Briton in India. A Pocket Interpreter containing Phrases and Travel Talk, &c. By I. A. Shap. London : Leopold B. Hill. [Price 2s. net.]

Reports of the Progress of Applied Chemistry. Issued by the Society of Chemical Industry. Vol. II, 1917. London : Society of Chemical Industry, 46–47, Finsbury-square, E.C. 2. [Price 6s. 6d. post free.]

Fuel Economy in Boiler Rooms. In two parts. Part I. *Fuel Economy and CO_2 Recorders.* By A. R. Mauzer and Charles H. Bromley. Part II. *Fuel Economy in Boiler Rooms.* By Charles H. Bromley. Second edition. London : Hill Publishing Company, Limited. [Price 12s. 6d. net.]

Personal.—We are informed that Mr. Freeman B. T. Trevelyan (Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, Openshaw) has joined the Board of the Manchester Steam Users' Association.

Record German War Profits.—The Ammendorf paper mills at Radewell have declared a record dividend and bonus for last financial year, inasmuch as the previous year's dividend of 36 per cent. has been maintained and a bonus of 50 per cent. (in war loan) added. Last year there was no bonus declared. The capacity of the company is taxed to the utmost limit for the whole of the current year, and the same high degree of employment is expected to continue for some time beyond.

WASTE HEAT FOR STEAM GENERATION.*

The Utilisation of Waste Heat from Open-Hearth Furnaces for the Generation of Steam.

By THOMAS B. MACKENZIE, M.I.Mech.E., Motherwell.

ABOUT twenty years ago the firm with which the author is connected was engaged in laying down a new smelting shop with acid-lined open-hearth furnaces of a nominal capacity of 60 tons, and it was decided to put boilers between them and the chimneys, with the intention of generating enough steam to blow the gas producers.

The boilers selected were of the Cornish type, 30 ft. long by 7 ft. diameter, with a single internal flue 42 in. in diameter. The waste gas from the furnace was divided into three streams, each of which travelled once along the length of the boiler, reuniting again at the chimney end. These boilers were duly erected and tried, but owing to the cooling effect on the gases the draught of the furnaces was reduced to such an extent that their operation was slowed down sufficiently to compel this attempt to recover the waste heat to be abandoned. The boilers were accordingly removed, re-erected in ordinary settings, and fired by hand in the usual way. Although this method of utilising the waste heat from the furnaces had proved abortive the author was not convinced that the problem could not be solved, and after giving the subject some thought it occurred to him that the placing of an induced draught fan beyond the boiler would be a solution.

In order to put his ideas on record he prepared a paper on the subject, which was read before the Institution of Engineers and Shipbuilders in Scotland on March 21, 1911, the title of the paper being "On Means for Economising Fuel and Utilising Waste Heat in Malleable Iron and Steel Works."

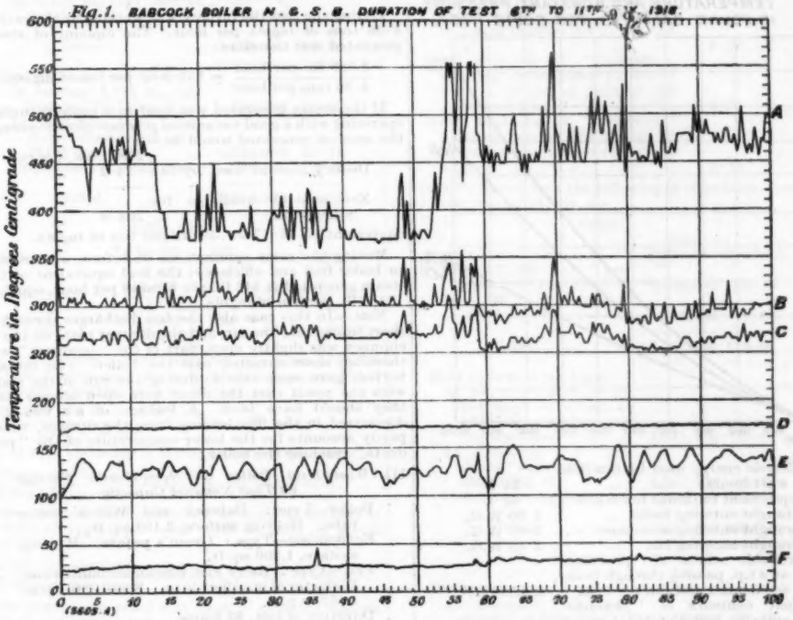
As a direct result of the paper the author was given permission to have an experimental boiler, economiser and fan, on the lines he had advocated, attached to one of the smaller furnaces in the works to test the predictions made.

The furnace selected for the experiment was an acid-lined open-hearth furnace of ordinary construction and of 30 tons nominal capacity. The boiler selected was of the Babcock and Wilcox water-tube type, having a heating surface of 1,619 sq. ft. In series with the boiler was placed a Green's economiser, having a heating surface of 720 sq. ft. The fan adopted was of the Keith and Blackman type, having an impeller 20 in. diameter driven by a variable-speed direct-current motor of 20 brake horse-power. As originally erected, two openings were made in the steel chimney attached to the furnace—a lower one to admit the waste gases to the boiler, and a higher one for their return after passing over the heating surfaces of boiler and economiser, a cast-iron damper of the butterfly type being fitted in the chimney between the openings. This arrangement did not work satisfactorily, as the damper could not be kept tight. A plate damper was then fitted at the top of the chimney, the upper opening closed, and the fan arranged to discharge direct into the air. After some other minor troubles had been overcome the installation was got to work satisfactorily, and a test was made extending over a period of 111½ hours, in order that a fair average from all conditions of the furnace would be arrived at. See Fig. 1, below.

* Paper read before the Iron and Steel Institute, September 13, 1918.

The mean values of the observed data are as follows :—

Temperature of "products" entering boiler	504 deg. C.
Temperature of "products" leaving boiler and entering economiser	254 deg. C.
Temperature of "products" leaving economiser and entering fan	169 deg. C.
Temperature of cold feed entering economiser	11·6 deg. C.
Temperature of hot feed leaving economiser and entering boiler...	117·8 deg. C.
Steam pressure per square inch (gauge)	86·5 lb.
Dryness factor (assumed) ...	0·95
Weight of water evaporated per hour, actual	2,440 lb.
Weight of water evaporated per hour "from and at" ...	2,800 lb.
Weighing water evaporated "from and at" per square foot of boiler heating surface	1·73 lb.



A. Temperature of gas entering boiler.
B. Temperature of gas entering economiser.
C. Temperature of gas leaving economiser.
D. Temperature of steam in boiler.
E. Temperature of feed water entering boiler.
F. Temperature of feed water entering economiser.

Natural draught of chimney with boiler, &c., dampered off ...	0·6 in. W.G.
Draught at base of chimney with boiler, &c., on and fan running	0·8 in. W.G.
Probable volume of "products" at s.t.p. passing through boiler, economiser, and fan per hour ...	380,000 ft.³

From these data the following heat balance-sheets were calculated :—

Boiler.

Heat received per hour :	Lb. Calories.	Per Cent.
In 1,081,000 ft.³ "products" at 504 deg. C....	4,086,000	93·37
In 2,440 lb. hot feed at 117·8 deg. C.	289,700	6·63
Total	4,375,700	100·00
Heat expended per hour :		
In evaporation 2,440 lb. hot feed to steam at 101 lb. per square inch absolute and dryness factor 0·95	1,555,000	35·55
In 733,500 ft.³ "products" delivered to economiser at 254 deg. C.	1,972,000	45·06
Other losses (by difference)	848,700	19·39
Total	4,375,700	100·00

Economiser.

Heat received per hour :		
In 733,500 ft.³ "products" at 254 deg. C....	1,972,000	98·58
In 2,440 lb. cold feed at 11·6 deg. C.	28,310	1.42
Total	2,000,310	100·00
Heat expended per hour :		
In heating 2,440 lb. cold feed to 117·8 deg. C....	289,710	14·48
In 615,200 ft.³ "products" discharged at 169 deg. C.	1,292,000	64·60
Other losses (by difference)	418,610	20·92
Total	2,000,310	100·00

Efficiencies.

Boiler $= \frac{1,555,000 \times 100}{4,375,000} = 35·55$ per cent.

Economiser $= \frac{289,700 \times 100}{2,000,310} = 14·48$ per cent.

Over all $= \frac{1,555,000 \times 100}{4,114,310} = 37·80$ per cent.

The fan absorbed 14·3 Board of Trade units of electricity per hour.

During the trials the furnace was working at the rate of 2·25 tons of ingots per hour. The amount of steam generated was therefore $\frac{2,440 \text{ lb. per hour}}{2·25 \text{ tons per hour}} = 1,084$ lbs. per ton of ingots.

If the steam generated per hour had been used in a modern turbine with a good vacuum to generate electric energy the amount generated would have been :—

	158·0 B.T. units.
Deduct amount used by fan	14·3 ,,
Leaving a net amount of energy available for outside work of	143·7 ,,

Assuming boiler fuel to have a calorific value of 6,700 lb. calories per pound, and that ordinary steelwork boilers have an efficiency of 65 per cent., the fuel equivalent of the steam generated was 357 lb. per hour, equal to 158·7 lb. per ton of ingots.

If we divide the net amount of electric energy available for outside work by the rate of production of ingots, we obtain 63·86 Board of Trade units per ton, an amount which should be sufficient to roll the steel produced by the furnace.

These results having demonstrated that the author's arrangement was quite practicable and did not in any way interfere with the furnace output, it was decided to provide a new smelting shop in process of erection and containing open-hearth furnaces of 45 tons nominal capacity with similar equipment.

The equipment consists, for each furnace, of a Babcock and Wilcox water-tube boiler having a heating surface of 1,827 sq. ft., a Green's economiser having a heating surface of 960 sq. ft., and a Keith and Blackman fan with an impeller 30 in. diameter, driven by a variable-speed direct-current motor of 40 brake horse-power.

The fans discharge through short funnels direct into the atmosphere. The furnace chimneys have disc-plate dampers at the top, which are kept nearly closed when the boilers, economisers, and fans are in operation.

There are two reasons why the dampers are not closed fully, one being that the boilers and fans are rather small, and the other being a fear lest an explosive mixture would become pocketed in the chimney at each reversal of the furnace with the risk of "kicks" taking place which might cause damage to the plant.

This plant was finished and put to work shortly before the war broke out, so that no tests were made of their performance. Since the war the author has been jointly responsible for adding seven boilers and fans to old furnaces and 10 to new furnaces, and it is unfortunate that the theory was not developed, as, had it been done, larger boilers would have been used and more steam obtained.

A number of tests have now been run, details of which are given below :—

I. *Waste-Heat Boiler on Open Hearth Furnace of 45 Tons Nominal Capacity.*

Boiler—Type : Babcock and Wilcox water-tube. Heating surface, 1,827 sq. ft.
Economiser—Type : Green's patent. Heating surface, 960 sq. ft.
Fan—Type : Keith and Blackman multi-vane. Diameter of impeller, 30 in. Speed, 580 r.p.m.
Duration of test, 99 hours.
Readings taken at 20-minute intervals.

The following are the average values of the data observed :—

Temperature of "products" entering boiler	585·3 deg. C.
Temperature of "products" entering economiser	273 deg. C.
Temperature of "products" entering fan	181·6 deg. C.
Temperature of feed entering economiser	6·95 deg C.
Temperature of feed entering boiler	120·6 deg. C.
Steam pressure per square inch absolute	119 lb.
Dryness factor of steam (assumed)	0·95 lb.
Total water evaporated	393,251 lb.
Water evaporated per hour ...	3,972 lb.
Water evaporated per hour "from and at"	4·604 lb.
Evaporation "from and at" per square foot H.S.	2·52 lb.
Electric energy used by fan (kilowatt hours)	26·40 lb.
Equivalent to (brake horse-power)	31·85 lb.

PROBLEMS OF RECONSTRUCTION.

The following statement with regard to advisory bodies, other than reporting committees, appointed by the Minister of Reconstruction, was issued on Tuesday as a Parliamentary paper:—

The Minister of Reconstruction has appointed the following bodies, other than committees required to report on specific terms of reference, to advise him on different aspects of the various problems which come before him:—

1.—The Advisory Council.

The Advisory Council consists of a panel of men and women of mature experience and distinction in affairs, from whom the Minister of Reconstruction can obtain practical and competent advice on any questions of special difficulty or complexity that may arise in connection with the work of the Ministry. For working purposes the council is divided into five sections, each under the direction of a chairman and vice-chairman selected from the members of the council. The chairmen and vice-chairmen of the different sections of the Advisory Council meet, as a rule, once a week, to advise the Ministry informally on any points of difficulty that may arise in the daily work of the department, and to suggest convenient methods of machinery for approaching questions of great complexity and importance. An informal committee of women members of the council, under the presidency of Lady Emmott, will also meet regularly to give the Ministry similar advice in connection with questions affecting the position of women. The council is at present constituted as shown below, but additional members will be appointed from time to time, as may be necessary, in connection with further developments of the work of the council and of the Ministry as a whole.

Section I. (Finance, Transport and Common Services.)—Sir Charles Metcalfe, Bart. (who has acted as chairman in the absence of Sir H. Babington-Smith, K.C.B.), Sir Clarendon Hyde (vice-chairman), the Hon. Herbert Gibbs (financial chairman), Mr. E. Hussey (financial vice-chairman), Sir Alfred Booth, Bart., the Hon. Robert Brand, C.M.G., Sir E. Tootal Broadhurst, Mr. Vernon Hartshorn, O.B.E., Mr. W. L. Hichens, Mr. H. J. Mackinder, M.P., Sir Adam Nimmo, K.B.E., Major the Hon. George Peel, M.P., Sir Alexander Roger, Mr. Ernest E. Spicer, the Right Hon. J. H. Thomas, M.P., Sir W. Rowan Thomson, K.B.E., and Mr. Arthur Whitworth.

Section II. (Production and Commercial Organisation.)—Sir Henry Birchenough, K.C.M.G. (chairman), Mr. E. Bevin (vice-chairman), Mr. J. P. Boland, M.P., Sir E. Tootal Broadhurst, Mr. H. S. Clough, Sir Charles Fielding, K.B.E., Mr. W. T. Green, Mr. J. W. Hope, C.B.E., Mr. W. H. Hutchinson, Sir Clarendon Hyde, Mr. H. J. Mackinder, M.P., Mr. J. J. Mallon, Sir Alexander Roger, and Mr. W. H. Watkins.

Section III. (Labour and Industrial Organisation.)—The Right Hon. J. H. Thomas, M.P. (chairman), Mr. W. L. Hichens (vice-chairman), Mrs. E. Barton, Mr. E. Bevin, Sir H. Birchenough, K.C.M.G., Mrs. Butler, Mr. H. S. Clough, Mr. J. F. Duncan, Major-General Sir P. Girouard, K.C.M.G., the Right Hon. Lord Gorell, Mr. Vernon Hartshorn, O.B.E., Mr. J. W. Hope, C.B.E., Mr. W. H. Hutchinson, Mr. C. A. McCurdy, M.P., Mr. J. J. Mallon, Sir Thomas Munro, Sir Adam Nimmo, K.B.E., Mr. Edwin Orde, Sir H. B. Rowell, K.B.E., Mr. R. H. Tawney, Miss G. Tuckwell, and Mr. W. H. Watkins.

Section IV. (Rural Development, including Agriculture)—Mr. Leslie Scott, K.C., M.P. (chairman), Right Hon. Henry Hobhouse, P.C. (vice-chairman), Mr. C. R. W. Adeane, C.B. Mrs. E. Barton, Right Hon. C. W. Bowerman, M.P., Mr. G. Dallas, Mr. J. F. Duncan, Lady Emmott, Sir Charles Fielding, K.B.E., Sir Richard Glazebrook, K.C.B., F.R.S., Mr. Hugh A. Law, M.P., Mr. T. Lundon, Mr. George Nicholls, Major Hugh Pritchard, Major-General A. E. Sandbach, C.B., D.S.O., Hon. E. G. Strutt, Miss G. Tuckwell, Mrs. Roland Wilkins, Mr. David Wilson, and Professor T. B. Wood, C.B.E.

Section V. (Social Development, including Education, Health, Housing.)—Mr. Arthur A. Allen, M.P. (chairman), Lady Emmott (vice-chairman), Mrs. E. Barton, Right Hon. C. W. Bowerman, M.P., Sir Richard Glazebrook, K.C.B., F.R.S., the Right Hon. Lord Gorell, and Miss G. Tuckwell.

Women's Advisory Committee of the Council.—Lady Emmott (chairman), Lady Birchenough, Miss Beatrice Chamberlain, Mrs. Deane Streatfeild, Miss Harris, Miss Susan Lawrence, Dr. Marion Phillips, Mrs. Pember Reeves, Lady Rhondda, Miss Symons and Miss M. J. Tuke.

Advisory Council on the Disposal of Surplus Government Property.

This Council has been appointed "To reconsider and advise, under the direction of the Minister of Reconstruction, as to the manner in which all stores, land and other property (except shipping and Government factories), under the control of Government Departments, being property acquired for the purposes of the present war, and no longer required for the purposes of the departments under the control of which it is, shall be dealt with, whether by the transfer thereof to some other department, or by the sale or disposal thereof to other persons." It consists of the following members, together with representatives of the departments concerned:—

The Most Hon. the Marquess of Salisbury, K.G., G.C.V.O., C.B. (chairman), Sir Howard Frank, K.C.B. (vice-chairman), the Right Hon. W. Adamson, M.P., Mr. G. Lowes Dickinson, Mr. Philip Hamson, C.B., Sir R. Sothern Holland, Bart., Mr. W. Lander, Sir Maurice Levy, Bart., M.P., Captain Sir Beville Stanier, Bart., M.P., and Sir John E. Thornycroft, K.B.E.

Engineering Trades (New Industries) Committee.

This committee was appointed "to compile a list of the articles suitable for manufacture by those with engineering trade, experience, or plant, which were either not made in the United Kingdom before the war but were imported, or were made in the United Kingdom in small or insufficient quantities and for which there is likely to be a considerable demand after the war, classified as to whether they are capable of being made by (1) women, (2) men and women, (3) skilled men; and setting out the industries to which such new manufactures would most suitably be attached; and to make recommendations: (a) On the establishment and development of such industries by the transfer of labour, machines and otherwise; (b) as to how such transfer could be made, and what organisation would be requisite for the purpose, with due regard to securing the co-operation of labour.

The members of the main committee, together with the sub-committees which have been appointed to deal with particular industries, are as follow:—

The Hon. H. D. McLaren, M.P., C.B.E. (chairman), Mr. Charles Bennion, Sir George Bullough, Bart., Mr. F. H. Crittall, Mr. R. Dumas, Sir John Griffith, M.Inst.C.E., Mr. W. B. Lang, Mr. Charles A. Lister, C.B.E., Mr. P. J. Pybus, C.B.E., Mr. G. H. Sankey, Sir Percy Stothert, K.B.E., Mr. John Taylor, Mr. William Taylor, Mr. William Thom, Sir W. Rowan Thomson, K.B.E., and Mr. H. C. B. Underdown.

The Branch Committees are on Wire Machinery; Printing Machinery; Printers' General Machinery; Paper-making Machinery; Leather Manufacturing Machinery; Textile Machinery (Manchester); Textile Machinery (Nottingham); Machine Tools; Agricultural Machinery; Aircraft; Holloware, Sheet Metal, and Pressed Work; Electrical Apparatus; Scientific Instruments; Miscellaneous Machinery; Motor Industry; Labour Panel.

Supply of Raw Materials After the War.

In this connection the Minister of Reconstruction is being advised by committees to whom, for their general guidance, the following terms of reference have been given:—

1. To consider and report upon the nature and amount of the supplies of materials and foodstuffs which, in their opinion, will be required by the United Kingdom during the period which will elapse between the termination of the war and the restoration of a normal condition of trade, and the steps which should be taken to procure those supplies, having regard to:—

(a) The probable requirements of India, the Dominions and Crown Colonies for such supplies at the close of hostilities.

(b) The probable requirements of belligerents and neutrals for such supplies at the close of hostilities.

(c) The sources from which, and the conditions under which, such supplies can be obtained and transported, and, in particular, the extent to which they might be obtained from the United Kingdom or within the Empire, or from Allied or neutral countries.

2. To consider also whether any measure of control will require to be exercised, and the extent and character of such control.

The following are the individual committees:—Aluminium; Antimony; Copper; Lead; Nickel; Spelter; Tin; Ferro-Alloys; Asbestos; Hides and Skins.

Building Materials.

A special committee has been appointed to advise on the important questions connected with the supply of building materials. The War Cabinet recently set up a Cabinet Committee to deal with post-war priority questions and a standing Council on Post-War Priority, composed of representatives of employers and workpeople in various industries, is now at work.

GERMAN STEEL INDUSTRY WAR PROFITS.

The Hoesch Iron and Steel Works, Dortmund, has declared a dividend for last year of 24 per cent., in addition to an extra dividend of 15 per cent. The company has renewed its request for permission to increase its capital by 12,000,000 marks, which has become necessary by the purchase of the Fürst Leopold concern, for which 22,000,000 marks have to be paid in cash. Last year's production shows a material increase compared with that of the previous year, the value of products despatched from the iron works and rolling mills amounting to 152,540,000 marks, against 109,150,000 marks for the previous year. With regard to the future, the continually rising cost of production had not been followed by any rise in prices, except for coal, which was of minor importance, as the company itself used most of its production of coal.

The Bismarck Hütte again declares a dividend of 30 per cent., but for last year the capital entitled to dividend is 22,000,000 marks, against 16,000,000 marks the previous year. The gross profits amounted to 20,170,746 marks, against 16,994,214 marks for the previous year,, the available surplus for the two years being respectively 7,471,960 marks and 5,423,126 marks. Writings-off, &c., amounted to 11,544,756 marks. Through the arrangement with the Westphalian Steel Works, the company became possessed of more than three-fourths of the portions of the Neue Haardt iron ore mines at Weidenau, Siegen. During the year the company's holdings of war loan bonds had increased by 14,000,000 marks, and now amounted to 33,000,000 marks.

The Cast Steel Company Witten, has again declared a dividend of 27 per cent., although the net profit receded from 6,031,353 marks for the previous year to 5,413,271 marks. Material sums were devoted to welfare institutions of different kinds. The report draws attention to the increasing cost of production, whilst the maximum prices remain unaltered.

The Trier Rolling Mill has declared a dividend of 18 per cent. for last year, against 16 per cent. for the previous year, the net profits amounting to 1,626,964 marks, against 931,919 marks for the previous year. The works were fully employed.

The Annener Cast Steel Works again pay a dividend of 25 per cent.; the production showed a substantial increase, but the profits were not quite up to those of the preceding year; prospects were considered satisfactory.

The Lothringen Iron Works and Mining Company, Hildingen, pays a dividend of 12 per cent. for last year. The report said nothing definite concerning the prospects for the current year. The company's Kneutinger iron works certainly lay in the danger zone, but, so far, no serious harm has been done. The company's principal works are located at Troisdorf, in the Ruhr district, and at Düsseldorf, the first-mentioned works standing booked only at 39,000,000 marks, or about 25 per cent. of this large company's capital; the mines alone exceeded in value the share capital, in addition to which there were large "still" reserves. The reconstruction for peace work was in operation at all the works, and on the consummation of peace, work could be continued without any difficulty.

BOOKS RECEIVED.

The Mineral Industries of the United States: Petroleum: A Resource Interpretation. By Chester G. Gilbert and Joseph E. Pogue. Washington: Government Printing Office.

Technology. The Journal of the Manchester Municipal College of Technology. A Record of Investigations undertaken by Members of the College. Vol. IX. Manchester:

The Life and Letters of Joseph Black, M.D. By Sir William Ramsay, K.C.B., F.R.S. *With an introduction dealing with the Life and Work* of Sir William Ramsay. By F. G. Donnan, F.R.S. London: Constable and Co., Limited. [Price 6s. 6d. net.]

Department of the Interior—Canada. Water Resources Paper No. 20. *Report on the Interests Dependent on Winnipeg River Power with Special Reference to the Capital Invested and the Labour Employed.* By H. E. M. Kensit, M.Am.Inst.E.E. Ottawa: Published by authority of the Minister of the Interior.

Liquid Steel, its Manufacture and Cost. By David Carnegie, F.R.S.E., M.Inst.C.E., M.I.Mech.E., assisted by Sidney C. Gladwyn. Second edition. London: Longmans, Green and Co. [Price 30s. net.]

Canada Department of Mines. Annual Report on the Mineral Production of Canada during the Calendar Year 1916. By John McLeish, B.A., Chief of the Division of Mineral Resources and Statistics. Ottawa: Government Printing Bureau.

Mathematical Tables and Formulæ. By P. Abbott, B.A. London: Longmans, Green and Co. [Price 2s. net.

University of Illinois Bulletin No. 104. *Tests to Determine the Rigidity of Riveted Joints of Steel Structures.* By Wilbur M. Wilson and Herbert T. Moore, Urbana: University of Illinois; London; Chapman and Hall, Limited. [Price 25 cents.]

United States Bureau of Mines. Technical Paper No. 190. *Methane Accumulations from Interrupted Ventilation with Special Reference to Coal Mines in Illinois and Indiana.* By Howard I. Smith and Robert J. Hamon. [Price 15 cents.] No. 195. *The Tars Distilled from Bituminous Coal in Hand-Fired Furnaces.* By S. H. Katz. [Price 5 cents.] Washington: Government Printing Office.

United States Bureau of Mines. Bulletin No. 123. *Analyses of Mine and Car Samples of Coal Collected in the Fiscal Years* 1913 *to* 1916. By Arno C. Fieldner, Howard I. Smith, J. W. Paul and Samuel Sanford. Washington: Government Printing Office. [Price 50 cents.]

The Briton in India. A Pocket Interpreter containing Phrases and Travel Talk, &c. By I. A. Shap. London: Leopold B. Hill. [Price 2s. net.]

Reports of the Progress of Applied Chemistry. Issued by the Society of Chemical Industry. Vol. II, 1917. London: Society of Chemical Industry, 46–47, Finsbury-square, E.C. 2. [Price 6s. 6d. post free.]

Fuel Economy in Boiler Rooms. In two parts. Part I. *Fuel Economy and CO_2 Recorders.* By A. R. Maujer and Charles H. Bromley. Part II. *Fuel Economy in Boiler Rooms.* By Charles H. Bromley. Second edition. London: Hill Publishing Company, Limited. [Price 12s. 6d. net.]

Personal.—We are informed that Mr. Freeman B. T. Trevelyan (Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, Openshaw) has joined the Board of the Manchester Steam Users' Association.

Record German War Profits.—The Ammendorf paper mills at Radewell have declared a record dividend and bonus for last financial year, inasmuch as the previous year's dividend of 36 per cent. has been maintained and a bonus of 50 per cent. (in war loan) added. Last year there was no bonus declared. The capacity of the company is taxed to the utmost limit for the whole of the current year, and the same high degree of employment is expected to continue for some time beyond.

WASTE HEAT FOR STEAM GENERATION.*

*The Utilisation of Waste Heat from Open-Hearth Furnaces for the Generation of Steam.**

By Thomas B. Mackenzie, M.I.Mech.E., Motherwell.

About twenty years ago the firm with which the author is connected was engaged in laying down a new smelting shop with acid-lined open-hearth furnaces of a nominal capacity of 60 tons, and it was decided to put boilers between them and the chimneys, with the intention of generating enough steam to blow the gas producers.

The boilers selected were of the Cornish type, 30 ft. long by 7 ft. diameter, with a single internal flue 42 in. in diameter. The waste gas from the furnace was divided into three streams, each of which travelled once along the length of the boiler, reuniting again at the chimney end. These boilers were duly erected and tried, but owing to the cooling effect on the gases the draught of the furnaces was reduced to such an extent that their operation was slowed down sufficiently to compel this attempt to recover the waste heat to be abandoned. The boilers were accordingly removed, re-erected in ordinary settings, and fired by hand in the usual way. Although this method of utilising the waste heat from the furnaces had proved abortive the author was not convinced that the problem could not be solved, and after giving the subject some thought it occurred to him that the placing of an induced draught fan beyond the boiler would be a solution.

In order to put his ideas on record he prepared a paper on the subject, which was read before the Institution of Engineers and Shipbuilders in Scotland on March 21, 1911, the title of the paper being "On Means for Economising Fuel and Utilising Waste Heat in Malleable Iron and Steel Works."

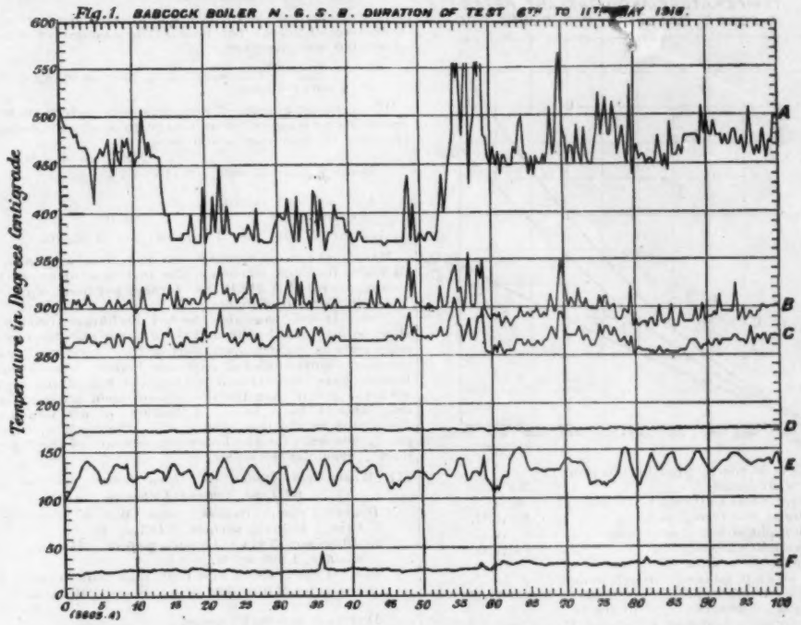
As a direct result of the paper the author was given permission to have an experimental boiler, economiser and fan, on the lines he had advocated, attached to one of the smaller furnaces in the works to test the predictions made.

The furnace selected for the experiment was an acid-lined open-hearth furnace of ordinary construction and of 30 tons nominal capacity. The boiler selected was of the Babcock and Wilcox water-tube type, having a heating surface of 1,619 sq. ft. In series with the boiler was placed a Green's economiser, having a heating surface of 720 sq. ft. The fan adopted was of the Keith and Blackman type, having an impeller 20 in. diameter driven by a variable-speed direct-current motor of 20 brake horse-power. As originally erected, two openings were made in the steel chimney attached to the furnace—a lower one to admit the waste gases to the boiler, and a higher one for their return after passing over the heating surfaces of boiler and economiser, a cast-iron damper of the butterfly type being fitted in the chimney between the openings. This arrangement did not work satisfactorily, as the damper could not be kept tight. A plate damper was then fitted at the top of the chimney, the upper opening closed, and the fan arranged to discharge direct into the air. After some other minor troubles had been overcome the installation was got to work satisfactorily, and a test was made extending over a period of 111½ hours, in order that a fair average from all conditions of the furnace would be arrived at. See Fig. 1, below.

The mean values of the observed data are as follows :—

Temperature of "products" entering boiler	504 deg. C.
Temperature of "products" leaving boiler and entering economiser	254 deg. C.
Temperature of "products" leaving economiser and entering fan	169 deg. C.
Temperature of cold feed entering economiser	11·6 deg. C.
Temperature of hot feed leaving economiser and entering boiler...	117·8 deg. C.
Steam pressure per square inch (gauge)	86·5 lb.
Dryness factor (assumed) ...	0·95
Weight of water evaporated per hour, actual	2,440 lb.
Weight of water evaporated per hour, "from and at" ...	2,800 lb.
Weight of water evaporated "from and at" per square foot of boiler heating surface	1·73 lb.

Fig. 1. BABCOCK BOILER N. G. S. B. DURATION OF TEST 6TH TO 11TH MAY 1918.



A. Temperature of gas entering boiler.
B. Temperature of gas entering economiser.
C. Temperature of gas leaving economiser.
D. Temperature of steam in boiler.
E. Temperature of feed water entering boiler.
F. Temperature of feed water entering economiser.

Natural draught of chimney with boiler, &c., dampered off ...	0·6 in. W.G.
Draught at base of chimney with boiler, &c., on and fan running	0·8 in. W.G.
Probable volume of "products" at s.t.p. passing through boiler, economiser, and fan per hour ...	380,000 ft.³

From these data the following heat balance-sheets were calculated :—

Boiler.

Heat received per hour :	Lb. Calories.	Per Cent.
In 1,081,000 ft.³ "products" at 504 deg. C....	4,086,000	93·37
In 2,440 lb. hot feed at 117·8 deg. C.	289,700	6·63
Total	4,375,700	100·00
Heat expended per hour :		
In evaporation 2,440 lb. hot feed to steam at 101 lb. per square inch absolute and dryness factor 0·95	1,555,000	35·55
In 733,500 ft.³ "products" delivered to economiser at 254 deg. C.	1,972,000	45·06
Other losses (by difference)	848,700	19·39
Total	4,375,700	100·00

Economiser.

Heat received per hour :		
In 733,500 ft.³ "products" at 254 deg. C....	1,972,000	98·58
In 2,440 lb. cold feed at 11·6 deg. C.	28,310	1.42
Total	2,000,310	100·00
Heat expended per hour :		
In heating 2,440 lb. cold feed to 117·8 deg. C....	289,710	14·48
In 615,200 ft.³ "products" discharged at 169 deg. C.	1,292,000	64·60
Other losses (by difference)	418,610	20·92
Total	2,000,310	100·00

Efficiencies.

$$\text{Boiler} = \frac{1,555,000 \times 100}{4,375,000} = 35{\cdot}55 \text{ per cent.}$$

$$\text{Economiser} = \frac{289,700 \times 100}{2,000,310} = 14{\cdot}48 \text{ per cent.}$$

$$\text{Over all} = \frac{1,555,000 \times 100}{4,114,310} = 37{\cdot}80 \text{ per cent.}$$

The fan absorbed 14·3 Board of Trade units of electricity per hour.

During the trials the furnace was working at the rate of 2·25 tons of ingots per hour. The amount of steam generated was therefore $\frac{2,440 \text{ lb. per hour}}{2{\cdot}25 \text{ tons per hour}} = 1,084$ lbs. per ton of ingots.

If the steam generated per hour had been used in a modern turbine with a good vacuum to generate electric energy the amount generated would have been :—

	158·0	B.T. units.
Deduct amount used by fan	14·3	,,
Leaving a net amount of energy available for outside work of	143·7	,,

Assuming boiler fuel to have a calorific value of 6,700 lb. calories per pound, and that ordinary steelwork boilers have an efficiency of 65 per cent., the fuel equivalent of the steam generated was 357 lb. per hour, equal to 158·7 lb. per ton of ingots.

If we divide the net amount of electric energy available for outside work by the rate of production of ingots, we obtain 63·86 Board of Trade units per ton, an amount which should be sufficient to roll the steel produced by the furnace.

These results having demonstrated that the author's arrangement was quite practicable and did not in any way interfere with the furnace output, it was decided to provide a new smelting shop in process of erection and containing open-hearth furnaces of 45 tons nominal capacity with similar equipment.

The equipment consists, for each furnace, of a Babcock and Wilcox water-tube boiler having a heating surface of 1,827 sq. ft., a Green's economiser having a heating surface of 960 sq. ft., and a Keith and Blackman fan with an impeller 30 in. diameter, driven by a variable-speed direct-current motor of 40 brake horse-power.

The fans discharge through short funnels direct into the atmosphere. The furnace chimneys have disc-plate dampers at the top, which are kept nearly closed when the boilers, economisers, and fans are in operation.

There are two reasons why the dampers are not closed fully, one being that the boilers and fans are rather small, and the other being a fear lest an explosive mixture would become pocketed in the chimney at each reversal of the furnace with the risk of "kicks" taking place which might cause damage to the plant.

This plant was finished and put to work shortly before the war broke out, so that no tests were made of their performance. Since the war the author has been jointly responsible for adding seven boilers and fans to old furnaces and 10 to new furnaces, and it is unfortunate that the theory was not developed, as, had it been done, larger boilers would have been used and more steam obtained.

A number of tests have now been run, details of which are given below :—

I. *Waste-Heat Boiler on Open Hearth Furnace of 45 Tons Nominal Capacity.*

Boiler—Type : Babcock and Wilcox water-tube. Heating surface, 1,827 sq. ft.
Economiser—Type : Green's patent. Heating surface, 960 sq. ft.
Fan—Type : Keith and Blackman multi-vane. Diameter of impeller, 30 in. Speed, 580 r.p.m.
Duration of test, 99 hours.
Readings taken at 20-minute intervals.

The following are the average values of the data observed :—

Temperature of "products" entering boiler	585·3 deg. C.
Temperature of "products" entering economiser	273 deg. C.
Temperature of "products" entering fan	181·6 deg. C.
Temperature of feed entering economiser	6·95 deg C.
Temperature of feed entering boiler	120·6 deg. C.
Steam pressure per square inch absolute	119 lb.
Dryness factor of steam (assumed)	0·95 lb.
Total water evaporated	393,251 lb.
Water evaporated per hour ...	3,972 lb.
Water evaporated per hour "from and at"	4·604 lb.
Evaporation "from and at" per square foot H.S.	2·52 lb.
Electric energy used by fan (kilowatt hours)	26·40 lb.
Equivalent to (brake horse-power)	31·85 lb.

* Paper read before the Iron and Steel Institute, September 13, 1918.

Draught entering boiler ...	...0·91 in. W.G.
Draught between boiler and economiser	...2·43 in. W.G.
Draught entering fan ...	...3·43 in. W.G.
Probable volume of "products" at s.t.p. passing through boiler, economiser and fan per hour ...	400,000 ft.³
Heat contents of "products" entering boiler at 585·3 deg. C. in pound calories per cubic foot s.t.p.	12·56
Heat contents of "products" entering economiser at 273 deg. C. in pound calories per cubic feet s.t.p.	5·59
Heat contents of "products" entering fan at 181·6 deg. C. in pound calories per cubic foot s.t.p.	3·66

From the above data the following heat balance-sheets have been calculated :—

Boiler.

	Lb. Calories.	Per Cent.
Heat received per hour :		
In 1,258,000 ft.³ "products" at 585·3 deg. C.	5,060,000	91·32
In 3,972 lb. hot feed at 120·6 deg. C.	481,400	8·68
Total	5,541,400	100·00
Heat expended per hour :		
In evaporating 3,972 lb. hot feed to steam at 119 lb. per square inch absolute and dryness factor 0·95	2,540,000	45·83
In 800,000 ft. "products" delivered to economiser at 273 deg. C.	2,237,200	40·38
Other losses (by difference)	764,200	13·79
Total	5,541,400	100·00

Economiser.

	Lb. Calories.	Per Cent.
Heat received per hour :		
In 800,000 ft.³ "products" at 273 deg. C....	2,237,200	98·77
In 3,972 lb. cold feed at 6·95 deg. C.	27,800	1·23
Total	2,265,000	100·00
Heat expended per hour :		
In heating 3,972 lb. cold feed to 120·6 deg. C. ...	481,400	21·25
In 666,200 ft.³ "products" discharged at 181·6 deg. C.	1,464,400	64·66
Other losses (by difference)	319,200	14·09
Total	2,265,000	100·00

Efficiencies.

$$\text{Boiler} = \frac{2,540,000 \times 100}{5,541,400} = 45{\cdot}83 \text{ per cent.}$$

$$\text{Economiser} = \frac{481,400 \times 100}{2,265,000} = 21{\cdot}25 \text{ per cent.}$$

$$\text{Over all} = \frac{2,540,000 \times 100}{5,087,800} = 49{\cdot}91 \text{ per cent.}$$

Theoretical power required to move 666,200 cub. ft. of "products" per hour at a temperature of 181·6 deg. C., with a suction of 3·43 in., water gauge is equal to 6 brake horse power. The efficiency of the fan is therefore :—

$$\frac{\text{Theoretical horse-power} = 6{\cdot}0}{\text{Actual horse-power taken} = 31{\cdot}85} = 18{\cdot}84 \text{ per cent.}$$

During the test the furnace was working at the rate of 4·18 tons of ingots per hour. The amount of steam generated was therefore :—

$$\frac{3,972 \text{ lb. per hour}}{4{\cdot}18 \text{ tons per hour}} = 949{\cdot}3 \text{ lb. per ton of ingots.}$$

If the steam generated were used in a modern turbine with a good vacuum to generate electric energy the amount would be :—

	= 253·2	kw.-hours.
Deduct amount used by fan	= 26·4	,,
Leaving a net amount...	= 226·8	,,

per furnace which is available for general purposes, equivalent to 54·2 kw.-hours per ton of ingots.

Making the same assumptions as before with regard to boiler fuel and efficiency, the fuel equivalent of the steam generated is 583·2 lb. per hour per furnace, equal to 139·4 lb. per ton of ingots.

Note.—As the damper on top of chimney was open slightly, the products of combustion accounted for in the test do not represent the whole amount available. Had the boiler been larger, more steam could certainly have been generated.

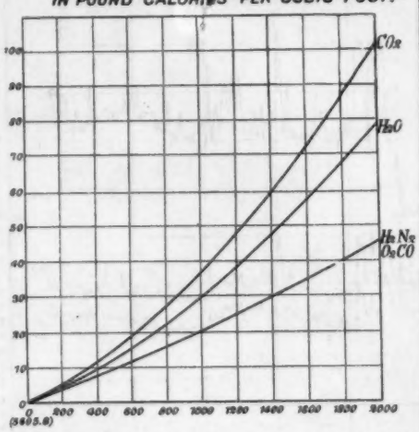
II. *Waste-Heat Boiler on Open-Hearth Furnace of 100 Tons Nominal Capacity.*

Boiler—Type : Babcock and Wilcox water-tube. Heating surface, 2,193 sq. ft.
Economiser—Type : Green's patent. Heating surface, 1,200 sq. ft.
Fan—Type : "Sirocco" multi-vane. Diameter of impeller, 50 in. Speed, 480 r.p.m.
Duration of test, 77½ hours.
Readings taken at 20-minute intervals.

The following are the average values of the data observed :—

Temperature of "products" entering boiler	...422·1 deg. C.
Temperature of "products" entering economiser	...232·4 deg. C.
Temperature of "products" entering fan	...184·4 deg. C.
Temperature of feed entering economiser	40·8 deg. C.
Temperature of feed entering boiler	...133·5 deg. C.
Steam pressure per square inch absolute	74 lb.
Dryness factor of steam (assumed)	0·95
Total water evaporated	228,306 lb.
Water evaporated per hour ...	3,728 lb.
Water evaporated per hour "from and at"	4,045 lb.
Evaporation "from and at" per square foot H.S.	1·84 lb.

Fig. 2. HEAT CONTENTS OF GASES AT VARYING TEMPERATURE AND CONSTANT PRESSURE IN POUND CALORIES PER CUBIC FOOT.



Electric energy used by fan (kilo-watt-hours)	24·2
Equivalent to (brake horse-power)	32·4
Draught entering boiler	1·60 W.G.
Draught entering economiser ...	3·05 W.G.
Draught entering fan	3·15 W.G.
Probable volume of "products" at s.t.p. passing through boiler, economiser and fan per hour ...	600,000 ft.³
Heat contents of "products" entering boiler at 422·1 deg. C. in pound calories per cubic foot s.t.p.	8·87
Heat contents of "products" entering economiser at 232·4 deg. C. in pound calories per cubic foot s.t.p.	4·73
Heat contents of "products" entering fan at 184·4 deg. C. in pound calories per cubic foot s.t.p.	3·72

From the above data the following heat balance-sheets have been calculated, viz. :—

Boiler.

	Lb. Calories.	Per Cent.
Heat received per hour :		
In 1,528,000 ft.³ "products" at 422·1 deg. C.	5,322,000	91·37
In 3,728 lb. hot feed at 133·5 deg. C.	503,100	8·63
Total	5,825,100	100·00
Heat expended per hour :		
In evaporating 3,728 lb. hot feed to steam at 74 lb. absolute and dryness factor 0·95 ...	2,360,000	40·52
In 1,111,000 ft.³ "products" to economiser at 232·4 deg. C. ...	2,838,000	48·72
Other losses (by difference)	627,100	10·76
Total	5,825,100	100·00

Economiser.

	Lb. Calories.	Per Cent.
Heat received per hour :		
In 1,111,000 ft.³ "products" at 232·4 deg. C.	2,838,000	94·91
In 3,728 lb. cold feed at 40·8 deg. C.	152,400	5·09
Total	2,990,400	100·00
Heat expended per hour :		
In heating 3,728 lb. cold feed to 232·4 deg. C....	503,100	15·34
In 1,006,000 ft.³ "products" discharged at 184·4 deg. C.	2,232,000	79·11
Other losses (by difference)	255,300	5·55
Total	2,990,400	100·00

Efficiencies.

$$\text{Boiler} = \frac{2,360,000 \times 100}{2,825,100} = 40{\cdot}52 \text{ per cent.}$$

$$\text{Economiser} = \frac{503,100 \times 100}{2,990,400} = 16{\cdot}83 \text{ per cent.}$$

$$\text{Over all} = \frac{2,360,000 \times 100}{5,474,400} = 43{\cdot}11 \text{ per cent.}$$

The theoretical power required to move 1,006,000 ft.³ "products" per hour, their volume at 184·4 deg. C. with a suction of 3·15 in. W.G. is :—

$$\frac{1,006,000 \times 3{\cdot}15 \text{ in.} \times 5{\cdot}2 \text{ lb.}}{60 \times 33,000} = 8{\cdot}32 \text{ b.h.p.}$$

The efficiency of the fan and motor is therefore :—

$$\frac{\text{Theoretical b.h.p.} = 8{\cdot}32}{\text{Actual b.h.p. taken} = 32{\cdot}4} = 25{\cdot}7 \text{ per cent.}$$

During the test the furnace was working at the rate of 4·36 tons of ingots per hour. The amount of steam generated was therefore :—

$$\frac{3,728 \text{ lb. per hour}}{4{\cdot}36 \text{ tons per hour}} = 855{\cdot}3 \text{ lb. per ton of ingots.}$$

If the steam generated was used in a modern turbine operating with a good vacuum to generate electric energy, the amount generated would be :—

	228·1	kw.-hours.
Deduct amount used by fan	24·2	,,
Net amount available for other work	203·9	,,

equivalent to 46·77 kw.-hours per ton of ingots.

Making the same assumptions as before, with regard to boiler fuel and efficiency, the fuel equivalent of the steam generated is 542 lb. per furnace per hour, equal to 124·4 lb. per ton of ingots.

Note.—In this case also the fan discharges through a short funnel into the air, and the damper plate on top of chimney was slightly open, part of the "products" was therefore short-circuited past the boiler. The furnace bottom gave some trouble during the run of the tests, with the result that the doors were open oftener than they should have been. A leakage of air was also discovered in the flue leading from the furnace, which partly accounts for the lower temperature of the "products" reaching the boiler.

III. *Waste-Heat Boiler on Open-Hearth Furnace of 60 Tons Nominal Capacity.*

Boiler—Type : Babcock and Wilcox water tube. Heating surface, 2,193 sq. ft.
Economiser—Type : Green's patent. Heating surface, 1,200 sq. ft.
Fan—Type : Keith and Blackman multi-vane. Diameter of impeller, 50 in. Speed, 240 r.p.m. to 320 r.p.m.
Duration of test, 93 hours.
Readings taken at 20-minute intervals.

The following are the average values of the data observed, viz. :—

Temperature of "products" entering boiler	...577·2 deg. C.
Temperature of "products" entering economiser	...302·8 deg. C.
Temperature of "products" entering fan	...171·5 deg. C.
Temperature of feed entering economiser	9·5 deg. C.
Temperature of feed entering boiler	...132·7 deg. C.
Steam pressure per square inch absolute	88 lb.
Dryness factor of steam (assumed)	0·95
Total water evaporated	429,213 lb.
Water evaporated per hour ...	4,616 lb.
Water evaporated per hour "from and at"	5,296 lb.
Evaporation "from and at" per square foot H.S.	2·41 lb.
Electric energy used by fan (kilo-watt-hours)	26·4 lb.
Equivalent to (brake horse-power)	35·4 lb.
Draught entering boiler	1·0 in. W.G.
Draught entering economiser ...	2·5 in. W.G.
Draught entering fan	3·0 in. W.G.
Probable volume of products reduced to s.t.p. cubic feet ...	600,000
Heat contents of "products" entering boiler at 577·2 deg. C. in pound calories per cubic foot s.t.p.	12·47
Heat contents of "products" entering economiser at 302·8 deg. C. in pound calories per cubic foot s.t.p.	6·24
Heat contents of "products" entering fan at 171·5 deg. C. in pound calories per cubic foot s.t.p.	3·45

From the above data the heat balance-sheets on the next page have been calculated.

Boiler.

	Lb. Calories.	Per Cent.
Heat received per hour :		
In 1,557,000 ft.³ "products" at 577·2 deg. C.	6,235,000	90·95
In 4,616 lb. hot feed at 132·7 deg. C.	619,400	9·05
Total	6,854,400	100·00
Heat expended per hour :		
In evaporating 4,616, lb. hot feed to steam at 88 lb. absolute and dryness factor 0·95 ...	2,934,000	42·81
In 1,043,000 ft.³ "products" delivered to economiser at 296·5 deg. C.	3,050,000	44·49
Other losses (by difference)	870,400	12·70
Total	6,854,400	100·00

Economiser.

	Lb. Calories.	Per Cent.
Heat received per hour :		
In 1,043,000 ft.³ "products" at 296·5 deg. C.	3,050,000	98·57
In 4,616 lb. cold feed at 9·5 deg. C.	43,900	1·43
Total	3,093,900	100·00
Heat expended per hour :		
In heating 4,616 lb. cold feed to 132·7 deg. C. ...	619,400	20·02
In 743,200 ft.³ "products discharged at 171·5 deg. C.	1,725,000	55·75
Other losses (by difference)	749,500	24·23
Total	3,093,900	100·00

Efficiences.

$$\text{Boiler} = \frac{2{,}934{,}000 \times 100}{6{,}854{,}400} = 42{\cdot}81 \text{ per cent.}$$

$$\text{Economiser} = \frac{619{,}400 \times 100}{3{,}093{,}900} = 20{\cdot}02 \text{ per cent.}$$

$$\text{Over all} = \frac{2{,}934{,}000 \times 100}{6{,}278{,}900} = 46{\cdot}73 \text{ per cent.}$$

The theoretical power required to move 743,200 cub. ft. of "products" per hour, their volume at 171·5 deg. C. with a suction of 3 in. W.G. is :—

$$\frac{743{,}200 \times 3 \text{ W.G.} \times 5{\cdot}2 \text{ lb.}}{60 \times 33{,}000} = 5{\cdot}86 \text{ b.h.p.}$$

The overall efficiency of fan and motor is therefore :—

$$\frac{\text{Theoretical b.h.p.} = 5{\cdot}86}{\text{Actual b.h.p. taken} = 35{\cdot}4} = 16{\cdot}54 \text{ per cent.}$$

During the test the furnace was working at the rate of 3·69 tons of ingots per hour. The amount of steam generated was therefore :—

$$\frac{4{,}616 \text{ lb. per hour}}{3{\cdot}69 \text{ tons per hour}} = 1{,}252 \text{ lb. per ton of ingots.}$$

If the steam generated was used to generate electric energy in a turbine of the type referred to above, the amount would be equal to 290 kw.-hours.

Deduct amount used by fan 62·4 kw.-hours

Leaving a net amount of ... 263·6 ,,

per furnace which is available for general purposes, equivalent to 71·52 kw.-hours per ton of ingots.

Making the same assumptions as before with regard to boiler fuel and efficiency, the fuel equivalent of the steam generated is 673·8 lb. per hour per furnace, equal to 182·8 lb. per ton of ingots at the rate of output at which the furnace was working during the test.

Note.—The fan in this case also discharges direct into the air through a short funnel, and during the test the main damper was slightly open at the top of the chimney.

It will be noted that the amount of "other losses" in the economiser is excessively large, due either to the pyrometer, by which the temperatures were taken at the outlet from the economiser, reading too low, or by leakage of air about the economiser causing the assumed volume to be too low. Probably both causes were in operation.

IV. *Waste-Heat Boiler on Open-Hearth Furnace of 60 Tons Nominal Capacity.*

Boiler—Type : Babcock and Wilcox water-tube. Heating surface, 2,193 sq. ft.
Economiser—Type : Green's patent. Heating surface, 1,200 sq. ft.
Fan—Type : Keith and Blackman multi-vane. Diameter of impeller, 50 in. Speed, 450 r.p.m.
Duration of test, 99¼ hours.
Readings taken at 20-minute intervals.
The readings are shown graphically on Fig. 1, page 567.

The following are the average values of the data observed :—

Temperature of "products" entering boiler	...438·9 deg. C.
Temperature of "products" leaving boiler and entering economiser	...303·7 deg. C.
Temperature of "products" leaving economiser and entering fan	...263·5 deg. C.
Temperature of cold feed entering economiser	...29·30 deg. C.
Temperature of hot feed leaving economiser and entering boiler...	129·2 deg. C.
Steam pressure per square inch absolute	122·7 lb.
Dryness factor (assumed)... ...	0·95
Total water evaporated	471,770 lb.
Water evaporated per hour ...	4,736 lb.
Water evaporated per hour "from and at"	5,301 lb.
Evaporation "from and at" per square foot H.S.	2·42 lb.
Electric energy used by fan (kilo-hours)	41·8 lb.
Equivalent to (brake horse-power)	56·0
Draught entering boiler ...	...1·00 in. W.G.
Draught between boiler and economiser	...3·75 in. W.G.
Draught entering fan ...	...5·75 in. W.G.
Probable volume of products passing through boiler, economiser and fan per hour reduced to standard temperature and pressure	950,000 ft.³
Heat contents of "products" entering boiler at 438·9 deg. C. in pound calories per cubic foot s.t.p.	9·26
Heat contents of "products" entering economiser at 303·7 deg. C. in pound calories per cubic foot s.t.p.	6·26
Heat contents of "products" entering fan at 263·5 deg. C. in pound calories per cubic foot s.t.p.	5·39

From the above data the following heat balance-sheets have been calculated, viz. :—

Boiler.

	Lb. Calories.	Per Cent.
Heat received per hour :		
In 2,477,000 ft.³ "products" at 438·9 deg. C.	8,792,000	93·46
In 4,736 lb. hot feed at 129·2 deg. C.	615,600	6·54
Total	9,407,600	100·00
Heat expended per hour :		
In evaporating 4,736 lb. hot feed to steam at 122·7 lb. absolute and dryness factor 0·95 ...	3,031,000	32·21
In 2,006,000 ft.³ "products" to economiser at 303·7 deg. C.	5,947,000	63·22
Other losses (by difference)	429,600	4·57
Total	9,407,600	100·00

Economiser.

	Lb. Calories.	Per Cent.
Heat received per hour :		
In 2,006,000 ft.³ "products" at 303·7 deg. C.	5,947,000	97·72
In 4,736 lb. cold feed at 29·3 deg. C.	138,800	2·28
Total	6,085,800	100·00
Heat expended per hour :		
In heating 4,736 lb. cold feed to 129·2 deg. C. ...	615,600	10·12
In 1,866,000 ft.³ "products" discharged at 263·5 deg. C.	5,121,000	84·16
Other losses (by difference)	349,200	5·72
Total	6,085,800	100·00

Efficiencies.

$$\text{Boiler} = \frac{3{,}031{,}000 \times 100}{9{,}407{,}600} = 32{\cdot}21 \text{ per cent.}$$

$$\text{Economiser} = \frac{615{,}600 \times 100}{6{,}085{,}800} = 10{\cdot}12 \text{ per cent.}$$

$$\text{Over all} = \frac{3{,}031{,}000 \times 100}{8{,}930{,}800} = 33{\cdot}93 \text{ per cent.}$$

The theoretical power required to move 1,866,000 ft.³ "products" per hour, their volume at 263·5 deg. C. with a suction of 5·75 in. W.G. is :—

$$\frac{1{,}866{,}000 \text{ ft.}^3 \times 5{\cdot}75 \text{ in. W.G.} \times 5{\cdot}2 \text{ lb.}}{60 \times 33{,}000} = 28{\cdot}18 \text{ b.h.p.}$$

The overall efficiency of fan and motor is therefore :—

$$\frac{\text{Theoretical b.h.p.} = 28{\cdot}18}{\text{Actual b.h.p. taken} = 56{\cdot}02} = 50{\cdot}28 \text{ per cent.}$$

During the test the furnace was working at the rate of 5·94 tons of ingots per hour. The amount of steam generated was therefore :—

$$\frac{4{,}736 \text{ lb. per hour}}{5{\cdot}94 \text{ tons per hour}} = 796{\cdot}9 \text{ lb. per ton of ingots.}$$

If the steam generated was used to generate electric energy in a turbine of the type referred to above, the amount would be equal to 320·2 kw. hours.

Deduct amount taken by fan 41·8 kw.-hours.

Leaving a net amount of ... 278·4 ,,

per furnace which is available for general purposes, equivalent to 46·81 kw.-hours per ton of ingots.

Making the same assumptions as before with regard to boiler fuel and efficiency, the fuel equivalent of the steam generated is 695·8 lb. per furnace per hour, equal to 117 lb. per ton of ingots at the rate of output at which the furnace was working during the test.

Note.—The fan in this case deals with the whole products of combustion, and after drawing them over the heating surfaces of boiler and economiser discharges them back into the chimney.

It will be noted that the efficiencies both of boiler and economiser are very low. This is due to the fact that they are too small for the volume of "products" passing through them.

That the boiler was working quite well is proven by the fact that it evaporated more water than No. III, although the temperature of the "products" was lower. The economiser, on the other hand, was not doing well, probably owing to the fact that it was working with hard water from a loch, with the result that the pipes may have been coated with scale. The high suction required at the fan inlet will also be noted due to the boiler being too small, and therefore the spaces between the tubes not being large enough for the volume of "products" being drawn through.

At the time of writing alterations are being made in the position of the baffles which will enable the "products" to flow more freely through.

(*To be continued.*)

THE STANDARDISATION OF TESTS FOR REFRACTORY MATERIALS.*

Communicated, with an Introduction, by Cosmo Johns, F.G.S., M.I.Mech.E.

(*Concluded from page 542.*)

III. The Identification of the Various Forms of Silica in Silica Bricks.

All the different modifications of silica (quartz, tridymite and cristobalite) possess physical characters by which each may be identified. Specific gravity, crystalline form and habit, and refractive indices, may, under certain conditions, be made use of for this purpose.

By a determination of the specific gravity quartz may be distinguished from the other forms of silica, and may be separated from them when in a finely divided state by the use of heavy solutions ; but the specific gravities of tridymite and cristobalite, even when these minerals are in a pure state, lie so near together that no practical separation according to density is possible.

Owing to the small size of the grains and crystals in which the higher temperature forms of silica usually exist, it is obvious that the best means of identification come within the field of microscopical examination, and for this purpose either thin sections or powders may be used.

The crystalline form and habit are best studied by means of thin sections, and by their aid quartz is clearly distinguished from the two other forms of silica. Usually tridymite may be identified by the shape of its crystals and mode of twinning, more especially when it has been recrystallised under long-continued heating. Often, however, both tridymite and cristobalite are present in silica bricks without any definite indication of crystalline form, and then some other means must be employed for their identification.

Between crossed nicols quartz is easily distinguished, by its greater power of birefringence, from tridymite and cristobalite ; but here again there is no possibility of separating the last-mentioned minerals from each other, for both are birefringent, and only feebly so, at ordinary temperatures.

There remain, therefore, the all-important methods that depend upon the utilisation of those most characteristic physical constants of these three minerals, namely, the refractive indices.

The differences between the mean refractive indices of quartz (1·549), tridymite (1·477), and cristobalite (1·484) are sufficiently well marked to give us a definite means of identification, and the methods employed may be either that of Becke or that of Schröder van der Kolk.

These methods are familiarly known as immersion methods from the fact that the material to be examined, powdered to a degree of fineness sufficient to ensure a separation of the component minerals, is placed in a liquid of known refractive index. The Becke or bright-line method, familiar to all petrologists, is that most often employed, and is no doubt generally applicable, for it furnishes a sensitive method of comparing the mean refractive index of any mineral with the refractive index of the liquid in which it is placed.

A still better method is that of Schröder van der Kolk, which is less well known. It is easy of application, yields results that are sensitive to a degree, and depends upon the fact that the dispersive powers of solids and liquids are seldom comparable. Even if a solid and a liquid have identical refractive indices for the light of the central portion of the spectrum, they will seldom have identical indices for red or for blue light. In such a case yellow light passing from the liquid into the mineral will suffer no refraction, but red and blue rays will be refracted and will give rise to red or blue fringes on one side or other of the dividing surface.

The method has been described by Schröder van der

* Paper read before the Iron and Steel Institute.

Kolk in his work entitled "Kurze Anleitung zur Mikroskopischen Krystallbestimmung," published at Wiesbaden in 1898. A discussion and practical exposition of the method was contributed by Mr. Allan Dick as an appendix to the "Kaolin, China Clay, and China-stone Handbook," Mem. Geol. Survey, 1914.

The method consists in viewing on a dark ground fragments of minerals placed in a liquid of approximately their own refractive index and illuminated by oblique white light from all sides.

If a mineral and a liquid have the same refractive index for yellow light, then the mineral, if viewed under the conditions mentioned above, will have deep ultramarine coloured fringes. If the liquid is of higher refractive index the blue colour is paler and brighter, until with yet higher indices the fringes are composed of white light. If the liquid is of slightly lower refractive index for yellow light than the mineral, red and orange fringes result, and this colour becomes paler and brighter as the refractive index of the liquid is diminished.

If, therefore, we make a solution of mercury-potassium-iodide in water, and dilute it until its refractive index for sodium light is 1·477, the mean refractive index of tridymite, and place it in powdered tridymite, the individual grains of this mineral, when viewed in the manner described, will show the characteristic ultramarine fringes. The same liquid, however, if used for cristobalite (R.I. 1·484), which has a slightly higher refractive index than tridymite, will give with this mineral orange-coloured fringes, while quartz has a refractive index so far removed from that of the liquid that it will be fringed with white light. It is thus possible to distinguish in one preparation the three minerals quartz, tridymite and cristobalite.

To take a simple case. A silica brick that has been in the flue of a furnace for a considerable period with one end raised to a temperature of about 1,600 deg. C., and the other seldom raised above 400 deg. C., will be clearly divisible into three parts: an outer part in which there appears to be no alteration and in which the original ganister fragments are obvious; a central black portion in which the ganister fragments gradually disappear towards the hotter end; and an inside white portion of granular texture in which all traces of the original ganister fragments are lost.

The central black portion consists almost entirely of recrystallised tridymite and ferruginous material with some quartz in the less altered portion. This, powdered finely and placed in a liquid of refractive index 1·477, will show a deep ultramarine colour with dark ground illumination; the white inside portion of the brick similarly powdered and placed in the same liquid will give a somewhat bright orange colour under the same circumstances, showing that in this portion of the brick the silica is all in the form of cristobalite.

There is no method at present known that can equal this either in ease of manipulation or in accuracy of results, for it can be applied in the case of the finest powders, and requires no calculations; the only necessary precaution is occasionally to standardise the immersion liquid. This may be done either by means of a refractometer or by immersing in the liquid powdered tridymite. Should the fringes be too bright or light blue the liquid needs dilution to give the proper ultramarine colour, while if the fringes are inclined to red or orange some concentration must be effected.

Owing to the rapidity and ease with which solutions of mercury-potassium-iodide absorb and give up water and thus change their concentration and refractive index, they should be kept securely stoppered, and are best used in microscopic work under a cover glass.

IV. The Porosity, Water Absorption, and Specific Gravity Tests.

The porosity of a brick is to some extent a measure of the density and texture of the brick. With firebricks, a high porosity usually means that a brick will withstand abrupt changes of temperature very well, but will have a low crushing strength. The porosity test is conducted as follows: A representative piece of the firebrick or refractory material to be tested is cut into rough cubes, about 2-in. size. The sample is dried at 110 deg. for about 2 hours and weighed. It is then soaked for some hours, preferably overnight, in water under reduced pressure—a vacuum desiccator is very suitable for this purpose. The piece is then weighed while suspended in water as in ordinary specific gravity determination; the surface water is wiped off, and the piece is again weighed. The porosity, or the volume of the pores expressed as a percentage volume of the whole piece, is 100 times the quotient obtained by dividing the difference between weights of the piece soaked and dried by the apparent loss in weight which the soaked piece suffers when weighed in air and then weighed suspended in water. Duplicates should agree within 0·2 per cent. With very dense or close-textured material, it is necessary to soak the sample for two or three days, otherwise the air bubbles in the centre of the piece are not displaced by water. The elimination of the air is also assisted by reducing the pressure inside the desiccator.

The specific gravity of the sample may also be calculated from the above data, since the apparent specific gravity of the lump is the quotient obtained by dividing the weight of the dry sample by the apparent loss in weight which the soaked piece suffers when weighed first in air and then suspended in water. The specific gravity of the solid material (powder) is the quotient obtained by dividing the weight of the dry test-piece by the apparent loss of weight which the dry piece suffers when weighed in air and then suspended in water—after soaking.

Unless "water absorption" is specifically required, it is best to use an oil like turpentine, kerosene, or paraffin in place of water, since the oil penetrates more rapidly into the pores.*

The specific gravity of the oil which is used must be determined. The procedure is the same as with water, but the quotient obtained in the way described above must be multiplied by the specific gravity of the oil. For example, if the weight of the dry test-piece be 24 grammes, and the apparent loss of weight when suspended in oil of specific gravity 0·84 be 8 grammes, then the true specific gravity of the material is $\frac{24}{8} \times 0{\cdot}84 =$ or 2·52.

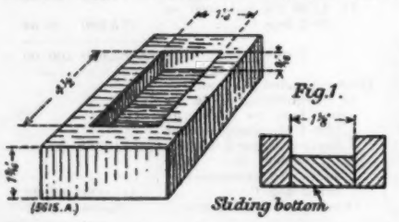
The apparent specific gravity of an average firebrick in lump usually varies from 1·5 to 1·9, and the powdered brick has a specific gravity ranging between 2·3 and 2·6; the porosity varies from 20 per cent. to 35 per cent.

V. The Shrinkage of Clays on Drying and Firing.

The clay, dried at a temperature not exceeding 70 deg., should be crushed to pass a 28's sieve, made up with water to the proper working consistency,† and thoroughly plugged or wedged. The clay is then moulded in a suitable mould made of metal or wood. The size recommended by the Committee on Standards of the American Ceramic Society (1918) is satisfactory. It is indicated in Fig. 1. The inside of the mould is thinly and evenly oiled with a rag soaked in paraffin oil. A piece of the clay rather larger than is required to fill the mould is patted into a roll about 4 in. long and vigorously projected into the mould so that the clay spreads and fills the lower corners and edges. The fingers must be free from oil. The excess of clay is then cut off with a wire and the surface slicked with a palette knife or rubber slicker. The test-piece so moulded is then marked——with the vertical lines about 9 cm. apart, and allowed to dry first at the room temperature, then at 70 deg. to 80 deg. (4 hours to 5 hours), and finally at about 110 deg. A portion of the clay from which the briquette was moulded is weighed on a watch glass, and after drying at 110 deg. is again weighed. The weight of water lost in drying is expressed as a percentage of the final weight of the dry piece.

The distance of the marks apart is again measured, and the linear drying shrinkage is expressed as a percentage of the length of the wet piece.

The test-pieces are then fired in a suitable muffle or thin-walled saggar. The effective firing space should



be greater than 2 cub. ft. The fuel employed may be solid fire, gas or oil. The rate of heating should not exceed five cones, or 100 deg. per hour, until approximately 900 deg. or cone 010a is reached, after which the rate of heating is decreased to about one cone per hour till the end of the operation.

For temperatures up to cone 6a (1,200 deg.), a thermocouple pyrometer should be used in order to check fluctuations of temperature. The atmosphere in the kiln should be oxidising.

For low-grade clays, test-pieces can be drawn from the kiln at cones 010a (900 deg.), 08a (940 deg.), 05a (1,000 deg.), 02a (1,060 deg.), 1 a (1,100 deg.), 4a (1,160 deg.), cone 6a (1,200 deg.). For higher-grade clays, test-pieces can be drawn from the kiln at cones 010a (900 deg.), 05a (1,000 deg.), 1a (1,100 deg.), 4a(1,160 deg.), 6a (1,200 deg.), 8 (1,250 deg.), and 10 (1,300 deg.). If desired, the firing can be carried still higher, say, to cones 12 (1,350 deg.), 14 (1,410 deg.) and 16 (1,460 deg.). When the test-pieces are removed from the kiln they are to be covered with hot sand, and kept at about 700 deg. in an auxiliary furnace until all the test-pieces have been drawn. The pieces are then allowed to cool at the normal rate of the furnace.

The test-pieces when cold are examined, adhering particles of sand brushed off. The firing contractions of the different test-pieces are then measured and the results expressed as a percentage of the length of the wet piece, wet to fired and also dry to fired. The porosities are also determined. The results can be plotted on squared paper, with the temperatures or cones as abscissæ, and contractions or porosities as ordinates. The curve will show the approximate firing temperature required to obtain the maximum contraction of the clay; and the higher temperatures will show if the clay is likely to bloat.

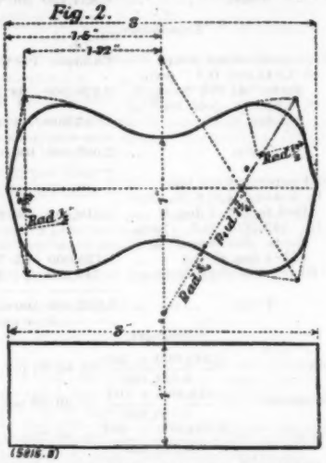
The colour changes should be noted, and the relative hardness as compared by cutting or scratching with a steel knife. The specific gravity can also be determined at the same time as the porosity.

VI. Tensile Strength of Dried Clays.

The tensile strength or tenacity of a clay or a body mixture is measured by the resistance which the dried clay offers to being pulled apart. The tensile strength of a clay has an important influence on the losses which occur during the manufacturing processes. Cases also arise during the manufacture of special refractories, graphite crucibles, grog bricks, &c., where the strength of the bonding clay is very important. The tensile strength test is not an easy one to make satisfactorily.

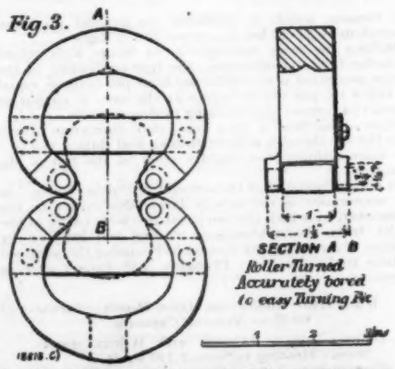
It is exceedingly difficult to prepare the clay satisfactorily for this test. The prepared clay must be free from air blebs and laminations. It requires some practice to be able to make the briquettes with a homogeneous texture in all directions. Faults in the making and drying of the briquettes are shown up by the irregular fractures. The drying of fine-grained clays without the development of very fine cracks is difficult. Such cracks cannot always be detected by inspection, but they are sources of weakness in the tensile machine and they lead to erratic results. There are several kinds of cement-testing machines available for this test.

Making of Test-Pieces.—The test-piece or briquettes are made in plaster moulds and have approximately the shape and size indicated in Fig. 2 when ready for breaking. For the sake of uniformity the size indicated in Fig. 2



may be taken. It is convenient also for clays. The manner in which the jaws grip the piece is very important, and needs careful adjustment in order to avoid shearing stresses. A suitable form of grip for clays is indicated in Fig. 3; it is modified from that recommended by the American Society for Testing Materials in Standard Specifications for Cement. The clay before use must be well prepared and uniform in composition and mixed with enough water to develop the maximum plasticity. The required uniformity and homogeneity is obtained by hand-wedging. The pressure used in making the test-piece should be regular and uniform. Strong clays or heavily grogged mixtures require some skill in making the briquettes if concordant results are to be obtained. The test-pieces must be slowly dried in air. Irregular drying introduces internal strains, especially in close-grained clays.

The Test.—The primary lever is first balanced in an horizontal position, and the test-piece is placed between the two jaws. Careful centering is necessary to ensure a direct pull. The bottom jaw is lowered by turning the small hand wheel until the test-piece is lightly



gripped. Leaden shot is run into the loading bucket from a metal cylinder. The loading must be done at a slow uniform rate, because, if added suddenly, shock, as distinct from the amount of tension, may rupture the more fragile clays. Pieces which show internal flaws about the fractured surface, and pieces which do not break within a quarter of an inch from the middle of the briquette, are discarded. The cross-sectional area at surface of fracture is measured (inches) and the shot weighed (pounds). Each machine has its own constant. The constant for the machine indicated in Fig. 3 is 50. Accordingly, the quotient,

$$\frac{\text{Weight of shot in lb.} \times 50}{\text{Area of fracture in sq. in.}}$$

represents the tensile strength in pounds per square

* For the difficulty with sealed pores, see *Transactions of the Ceramic Society*, 1907, vol. vii, page 80.

† This subject will be treated in later report. It might be added that it is difficult for one not accustomed to working clays to prepare the clay for this test.

inch. The average of five or six tests should be taken for each clay.

VII. Determination of the After-Contraction or After-Expansion of Refractory Materials.

This test is designed to find the after-contraction or after-expansion of a firebrick, i.e., the approximate change in size which the brick is likely to undergo when in use at high temperatures. This is sometimes called the permanent contraction (or expansion), but this term might then be confused with the contraction or expansion which occurs when the bricks are first fired. It is therefore recommended that the term "after-contraction" or "after-expansion" be reserved for the result of the present test. The temperature for testing recommended by the Gas Engineers' Specification is equivalent to cone 14 (1,410 deg. C., 2,570 deg. F.) for firebricks and material containing under 80 per cent. of silica, and cone 12 (1,350 deg. C., 2,462 deg. F.) for silica bricks and siliceous materials containing the equivalent of 80 per cent. or more of silica.

In making the test, a rectangular piece of the material —about 3 in. in length and 1 in. to 2 in. in width and depth—is cut across the end and one across the middle of the sample. The sample brick is selected from the middle of the setting. The opposite ends are ground parallel on an emery or carborundum wheel, and the length measured by means of a vernier gauge reading to 0·005 cm. The piece is then fired until the proper cone squats, and it is maintained at this temperature for 2 hours. After the cone has squatted a pyrometer is required to check the fluctuations of temperature. A gas furnace worked with an air blast is used, with an oxidising atmosphere. When cold the length of the test-piece is again measured and the alteration in size calculated.

The test is best done in duplicate, one piece cut from one end and one cut from the inside of the sample, and information is then obtained as to the uniformity of the firebrick.

Note.—The maximum contraction or expansion allowed by the Gas Engineers' Specification is: Silica bricks or siliceous material, 0·75 per cent.; retort material, 1·25 per cent.; firebricks, grade I, 1·0 per cent.; and firebricks, grade II, 1·25 per cent. The testing temperature with siliceous materials corresponds with cone 12, and with fireclay material, cone 14. A number of users consider these tests are not sufficiently severe, and that the testing temperature should be raised.

VIII. Determination of Normal Refractoriness of Firebricks, Fireclays, &c.

A representative piece of the material is chipped or shaped into the form of a cone about 1½ in. in height. The cone is cemented to the centre of a refractory disc, about 2 in. in diameter, by means of a mixture of ground bauxite and fireclay, and Seger cones are cemented around the test-piece. The cones are chosen in the order of increasing temperatures according to the material being tested. The cones should be sloped slightly in the outward direction, so that they will not fall on to the test-piece when they melt. The disc is placed on the supports of the lifting table of a Hirsch or similar electric furnace.

The initial energy is 2 kw. or 3 kw. The temperature of the furnace must be increased regularly about 50 deg. per 5 minutes, until the first cone begins to melt. If the increase in temperature is too rapid the voltage must be adjusted by means of an adjustable transformer or resistance. The energy taken at high temperature varies from 7 kw. to 10 kw., and the voltage has to be varied according as the resistance of the furnace is high or low. The furnace works much better on an alternating than on direct current.

Approximate Squatting Temperatures of Seger Cones, when the Furnace occupies from 2 Hours to 6 Hours to Reach the Temperature in Question. If the Rate of Rise of Temperature be Slower, the Squatting Temperatures are Lower, and if the Rise be Faster, the Squatting Temperatures are too High.

Cone No.	Deg. C.	Deg. F.	Cone No.	Deg. C.	Deg. F.	Cone No.	Deg. C.	Deg. F.
022	600	1,112	02a	1,060	1,940	19	1,520	2,768
021	650	1,202	01a	1,080	1,976	20	1,530	2,786
020	670	1,238	1a	1,100	2,012	26	1,580	2,876
019	690	1,274	2a	1,120	2,048	27	1,61 0	2,930
018	710	1,310	3a	1,140	2,084	28	1,63 0	2,966
017	730	1,346	4a	1,160	2,120	29	1,650	3,002
016	750	1,382	5a	1,180	2,156	30	1,670	3,038
015a	790	1,454	6a	1,200	2,192	31	1,690	3,074
014a	815	1,499	7	1,230	2,246	32	1,710	3,110
013a	835	1,535	8	1,250	2,282	33	1,730	3,146
012a	855	1,571	9	1,280	2,336	34	1,750	3,182
011a	880	1,616	10	1,300	2,372	35	1,770	3,218
010a	900	1,652	11	1,320	2,408	36	1,790	3,254
09a	920	1,688	12	1,350	2,462	37	1,825	3,317
08a	940	1,724	13	1,380	2,516	38	1,850	3,362
07a	960	1,760	14	1,410	2,570	39	1,880	3,416
06a	980	1,796	15	1,435	2,615	40	1,920	4,388
05a	1,000	1,832	16	1,460	2,660	41	1,960	3,650
04a	1,020	1,868	17	1,480	2,696	42	2,000	3,632
03a	1,040	1,904	18	1,500	2,732	—	—	—

The cones should melt at an interval of at least 5 minutes; if two or more cones squat at nearly the same temperature the increase in temperature is too rapid, and this makes the softening point of the test-piece appear too high. The temperature at which the test-piece bends over, squats, or shows signs of fusion is taken as the softening point. At this point the current is switched off, the support lowered, and the disc containing test-piece and cones plunged into cold water. This prevents the disc, &c., breaking up on cooling. The softening point of the test-piece is deduced from the cone which bent down last. The squatting temperature of a Seger cone corresponds with the temperature at which the cone bends over with the tip on a level with the base. The selection of the right cones for an unknown sample is made by successive approximation. For example, cones 20, 26, 30, 32 and 35 would be placed on a refractory disc with the clay to be tested. If cones 20 and 26 are down, and 30 to 35 are standing when the clay squats, it would be inferred that the clay squats between cones 26 and 30. In a second trial, therefore, cones 26 to 30 would be placed on the disc with the clay. The softening point of the test-piece often comes between the squatting temperature of the two cones, since the one has gone down so completely and the other one just commenced to bend. The bending temperatures of Seger cones are given in the following table:—

The comparison of the squatting temperature of refractories with a standard cone is better than expressing the results in terms of a pyrometer reading. The use of the term squatting or softening temperature is also preferable to the term melting-point, since refractory materials rarely have a sharp melting-point.

IX. The Refractory Test under Load.

For reasons which are obvious, it is sometimes found that a firebrick can be satisfactorily used in the masonry of a furnace at higher temperatures than the normal squatting temperature of the brick, and conversely, when the refractory is subjected to load, it is usually found that the material fails at a much lower temperature than is indicated by the normal squatting temperature. It is therefore important to test the refractory while under load.

A simple furnace for this purpose can be readily built on the same principle as that used for refractories not under load.

The loading of the test-piece is attained by means of a lever system, a suitable leverage being 12 : 1 after due allowance has been made for the weight, supports, &c.

The test-piece is cut from the brick and ground to a rectangular block 3½ in. long and 2 in. cross-section. This presents a surface of 4 sq. in. to the load. The final measurements of the piece are taken with a micrometer slide gauge. Much depends upon the careful preparation of this block; if the ends are not parallel the weight will not act in a true vertical direction, but tend to thrust sideways.

A solid refractory is bedded at the bottom of the inner tube of the surface. A thin layer of powdered carborundum is spread over the top of the basal support to prevent the sticking of the test-piece. The test-piece is placed centrally on the support so that all is quite level. Small Seger cones, arranged in series of four, are fixed on the basal support round the test-piece. A cube, 2½ in. square, made of similar material to the bottom support, is placed on top of the test-piece; this is followed by a cylinder, say, of magnesite and finally a carbon rod mounted in an iron ring. The carbon rod is attached to the lever arm in such a way that it can be moved horizontally so as to counteract any slight irregularities in supports.

If the temperature of the furnace rises too quickly there will be too large a difference between the temperature of the interior and exterior of the test-piece, and the results will be too high, because the temperature is of necessity measured on the outside of the test-piece, and the outside is always hottest. If the temperature rises at such a rate that cone 16 squats in about 4 hours, the difference between the temperature of the interior and exterior of the test-piece is about 20 deg. The rate of heating is controlled by means of variable transformers and resistances, the energy used varying from 6 kw. to 10 kw. As the temperature of the furnace rises the thermal expansion of the brick causes the lever arm to rise, but later the lever begins to fall. The rate at which the deformation proceeds depends on the character of the test-piece. When the squatting has reached the limit decided upon the current is switched off, the weights, lever and supports removed, and the cones observed. The test-piece is left in the furnace until it has cooled.

X. The Thermal or Reversible Expansion of Refractories, or the Hot and Cold Sizes of Firebricks.

The change in the volume, or rather the linear dimensions, which occur when a brick is heated to the temperature of the furnace, is called the thermal or reversible expansion of the brick for that temperature, and the results are averaged to express the change in linear dimensions which occur when unit length of the brick is heated 1 deg. This constant is quite different from the permanent change in volume—the after-expansion or after-contraction—which occurs when an imperfectly-fired brick is heated in a furnace. The two effects may interfere with one another.*

The thermal or reversible expansion is conveniently measured by Coppée's apparatus. This consists of a horizontal cathetometer, with a standard metre scale for measuring the amount of expansion, and a furnace for heating the bricks.

The cathetometer consists of a pair of sighting telescopes clamped on a metal bar which is mounted on a pivot and is capable of being revolved in a true horizontal plane. Both telescopes are fitted with two fixed cross-wires, and the right-hand telescope has also a movable vertical cross-wire attached to a delicate micrometer screw. The standard metre scale is made of invar metal graduated in centimetres and millimetres. For testing an ordinary (9-in.) firebrick a gas-blast furnace having a chamber about 24 in. long, 12 in. wide, and 9 in. high, which attains a temperature of 1300 deg., is suitable. Two small openings about 8 in. apart are required on either the side or door of the furnace for the purpose of focusing on the brick. The temperatures can be estimated by Seger cones or measured by a Féry or other optical pyrometer.

The brick is prepared by making two saw cuts of not less than 1 in. in depth and ¼ in. from each end, on the 9-in. by 3-in. face of the brick. A thick platinum wire, with one end finely pointed, is then fixed in each cut so that one end of each of the wires projects about ¼ in. above the top of the brick.

The brick is levelled horizontally in the furnace, so that the points of the wires are visible through the holes in the door of the furnace. The cathetometer is placed about 5 ft. or 6 ft. from the brick, and the two telescopes are adjusted so that the cross-wires exactly coincide with the tips of the platinum wires in the bricks. The distance between the platinum points is now measured on the standard scale.

For this purpose the scale is fixed in a convenient place and at the same distance from the cathetometer as the platinum wires of the brick. One of the centimetre divisions on the scale is made to coincide exactly with the fixed cross-wires on the left-hand telescope. Suppose this division is 46 cm. and the cross-wires of the right-hand telescope lie between 67 cm. and 68 cm. The distance between the platinum points is therefore greater than 21 cm. but less than 22 cm. The fractional part of a centimetre to be added to 21 cm. is obtained by using the micrometer screw (1) to measure the number of turns necessary to move the movable cross-wires from the 67-cm. to the 68-cm. division, and (2) to measure the number of turns necessary to bring the movable cross-wires from the position of the fixed vertical cross-wire to the 67-cm. division. For example, suppose that when the vertical cross-wire coincides with the 67-cm. division, the reading on the graduated head of the micrometer is 641. The reading when the fixed and movable cross-wires are in coincidence is, say, 683. After again turning the graduated head until the 68-cm. line is reached, suppose the reading is 707. Consequently, 707 − 641 = 66 divisions on the micrometer screw correspond to 1 cm. on the standard scale, and 683 − 641 = 42 divisions on the micrometer screw correspond to the fraction of a centimetre to be added. Therefore the fraction is 42/66 = 0·636 cm. The distance between the platinum points is therefore 21·636 cm. The furnace is then heated up and similar readings are taken at the required temperature. This enables the difference between the hot and cold size of the brick to be computed. The coefficient of thermal expansion or the expansion for unit length per degree (C. or F.) can also be computed. If desired the length of the brick can be plotted for a series of different temperatures.

XI. Crushing Strength—Cold.

The mechanical strength of refractory materials is one which needs consideration, since, when a firebrick is enclosed by a mass of brickwork, the weight of the superincumbent material, together with the thermal expansion of the brick, may produce considerable pressures. Usually, however, the crushing strength is well above general requirements.

The crushing strength test may be conveniently carried out with one of the many forms of crushing machines on the market, such as Weber's machine. This consists of a vertical cylinder filled with castor oil, and is provided with a movable piston and a horizontal shaft. The shaft is connected by means of gear wheels to one set of loose and two driving pulleys. By the rotation of one of these pulleys the shaft is driven into the cylinder, and the pressure is communicated through the oil to the piston, which is thus forced slowly upwards. By the rotation of the other driving pulley the motion of the shaft is reversed, and consequently this lowers the piston into the drum so as to obtain the maximum working space between the jaws of the press. When the horizontal shaft is worked by hand the results are not so regular, on account of the variable speed at which the test-piece is compressed; with power the speed is regular and constant.* The piston rises at the rate of 0·25 in. per minute. The pressure is recorded on the two gauges at the front of the press, the right-hand gauge being for low pressures only and the other for high pressures. The brick to be tested, say a 9-in. by 4½-in. by 3-in. firebrick, must first have its horizontal faces ground parallel and its vertical sides at right angles to these.†

The brick is placed on the middle of the rectangular iron plate at the top of the piston, so that the 9-in. by 4½-in. face is horizontal, and the movable iron plate on which the brick rests is levelled. The horizontal shaft is withdrawn as far as possible; the top plate is lowered on to the brick by means of the hand screw until the gauge shows a slight pressure. The horizontal shaft is then driven so as to compress the brick. When the brick collapses the pressure is taken off, and the crushing strength read by means of the pointer on the gauge. At least five bricks should be tested to ensure a fair average result—if one or two bricks only were tested these might be unsound, and consequently vitiate the result.

It will be observed that some bricks chip at the corners or edges, or develop internal cracks, some time before the maximum pressure is attained. The gauge reading is taken when the brick collapses; at the same time the indicator needle drops rapidly. To obtain concordant

* Transactions of the Ceramic Society, 1917, vol. xvi, page 270.

* The power drive is a later addition not on the original machine.

† Some prefer levelling slight irregularities with plaster of Paris or thick cardboard.

readings it is very important to eliminate all air bubbles from the oil in the drum. This is done by placing an iron block between the jaws of the machine and applying a high pressure for some time, occasionally opening the tap at the bottom of the cylinder. The cylinder is filled with oil by means of the small pump immediately above this tap.

The crushing pressure in pounds per square inch is calculated by multiplying the gauge reading by 93 (this being the area of the piston in square inches) and dividing the product by the area of the brick in square inches.

Example.—Area of brick = $8{\cdot}85 \times 4{\cdot}4 = 38{\cdot}94$ sq. in.
Gauge reading = 1,350.

$$\text{Crushing strength} = \frac{1{,}350 \times 93}{38{\cdot}94} =$$

3,224 lb. per square inch.

GASES OCCLUDED IN STEEL.*

By Thomas Baker, D.Sc., M.Met., F.I.C.

It is well known that iron and steel are capable of holding in solution or otherwise considerable quantities of gas, and that these are often far from negligible. Many investigators have attacked the problem with the object of ascertaining the composition and volume of these gases and their effect on the physical properties of the metal, but little is known on this subject beyond the part they play in the production of blowholes, and in a peculiar kind of brittleness which is developed by pickling.

Some years ago the author carried out an investigation with the above-mentioned object, and also to discover the relation, if any exists, between the temperature of evolution of the gas and the critical points of the steel.

For this purpose two crucible steel ingots about 6 cm. square were prepared in such a way that whilst one was free from blowholes the other contained as many as possible. In addition to this material there were also obtained some samples of dead soft steel such as is employed in the manufacture of tin plates. The chemical analyses of these materials are given in Table I.

Table I.

—	C.	Sil.	Mn.	S.	P.	Al.	F_2.
Solid ingot	0·99	0·088	0·096	0·023	0·019	0·033	99·01
Ingot with blowholes	0·81	0·080	0·050	0·028	0·019	—	98·84
Soft steel ingot ..	0·13	0·011	0·370	0·053	0·075	—	99·36

The apparatus employed for the extraction of the gases consisted of a porcelain tube glazed internally and externally and closed at each end by rubber stoppers. Through one of these passed a glass tube, making connection with a Torpler mercury pump, and through the other two glass tubes into which the leads from the thermocouple were fused. An electric resistance furnace was employed to heat the tube, and in order to prevent undue heating of the rubber stoppers the ends of the tube were water-cooled. The temperatures were determined by a thermocouple used in connection with a millivoltmeter.

Before starting an actual experiment it was thought advisable to run a blank; accordingly the tube and pump were thoroughly dried by drawing a stream of dry air through them for several hours. The end of the tube away from the pump was then sealed off and the tube exhausted and allowed to stand for 24 hours; the tube was then again exhausted and allowed to stand for a further 24 hours. At the end of this time continued working of the pump failed to pump anything out of the tube. It was next heated for nine periods of 8 hours each to a temperature of about 1,000 deg. C. and exhausted at the end of every third period. The composition and volume of the gases obtained in these experiments are embodied in Table II.

Table II.

—	Volume in c.c.	CO_2.	H_2.	CO.	CH_4.	N_2.
First period ..	0·84	15·48	40·00	—	19·05	25·47
Second period ..	1·15	18·25	52·20	11·22	5·48	12·78
Third period ..	1·18	4·23	73·22	13·55	5·93	3·13

No correction has been made for these gases in the appended results on the gases obtained from the various samples of steel.

In this connection it is interesting to note that Fox† found that thoroughly dried oxygen, when swept through an otherwise empty red-hot porcelain tube, persistently yielded small quantities of water—3·5 mgr. during the first hour, 0·7 mgr. from the twelfth to fourteenth hours.

A piece of one of the steels, weighing about 60 grammes and having a thermocouple inserted in one end, was next placed in the tube, the latter exhausted, and the vacuum maintained for 48 hours before starting the heating of the tube. After again exhausting the tube the experiment was commenced and continued over 10 days, the period of heating being 11 hours per day; and at intervals during each day the gas was collected and analysed. The volume and composition of the gases are given in Table III.

In the case of the steel with blowholes, as many as possible were cut open in order to allow the gases contained in them to escape, the object of the author being to obtain the gases from the solid portion of the steel, leaving those contained in the blowholes for a future investigation.

Some further experiments were carried out to ascertain the effect of such operations as annealing and mechanical work on the volume and composition of the gases. A piece of the sound steel was annealed at a temperature of about 1,200 deg. C. and the gas extracted in the manner already described; no marked changes were observed in either the composition or volume of the gases. No numerical results are given for this experiment, since they are simply a repetition of those already given for the same steel in the untreated condition.

In order to investigate the effect of mechanical work, an ingot from the same cast of soft steel as that already employed was rolled down from 9 in. square to a plate 9 in. wide by ¼ in. thick, and a piece selected from a position corresponding as nearly as possible to that of the piece from the first ingot. The results of this experiment are embodied in Table IV.

Table V.

Description.	Weight of Steel in Grammes.	Volume of gas per Gramme of Steel in c.c.	Volume of Gas in c.c.	Average Percentage Composition. CO_2.	H_2.	CO.	CH_4.	N_2.
Sound steel ..	69·3	1·32	91·86	1·68	52·00	45·53	0·72	0·07
Sound steel reheated ..	4·73	1·40	66·54	1·16	49·55	45·99	2·71	0·59
Steel with blowholes	42·1	0·66	63·20	0·88	54·56	42·36	1·73	0·47
Soft ingot ..	66·6	1·03	68·84	1·18	52·12	45·64	0·73	0·33
Bar from soft ingot	67·7	0·53	36·25	0·91	49·08	48·12	0·11	1·77

In Table V the results of all the experiments are collected. From these it appears that the composition is practically the same throughout the series, but that the volume varies considerably. In the case "sound steel" and "steel with blowholes," the variation in quantity is easily explained, since the latter before and whilst solidifying would boil off the greater part of the gas. In the case of the "soft ingot" also which contained an outer ring of blowholes, a smaller quantity of gas might reasonably be expected when compared with the sound steel. It is also evident that a mechanical operation such as rolling squeezes out a very considerable portion of the gas, which in the present case amounts to about one-half.

The thermal critical points of these steels occur at the following temperatures —

	Ac_1	Ac_2	Ac_3	Ar_1	Ar_2	Ar_3
Sound steel and steel with blowholes ...	deg.	deg. 746	deg.	deg.	deg. 693	deg.
Soft steel ingot and bar	722	758	867	682	760	846

With the hard steels hydrogen reaches a maximum rate of evolution at 600 deg., and below this temperature constitutes the greater part of the gas given off. Carbon monoxide is slowly evolved from the beginning of the experiment and reaches its maximum rate of evolution at 688 deg., a temperature which agrees fairly well with that of the Ar point.

With the soft steel hydrogen again forms the greater portion of the gas collected at temperatures up to 600 deg. and presents a maximum rate of evolution at 609 deg. It, however, differs from the hard steel in that it has a further maximum at 786 deg., the temperature at which the carbon monoxide also reaches its maximum rate of evolution. This latter temperature is approximately midway between the A_2 and A_3 points.

Whether these gases are the ones evolved from the steel or are formed by interaction between those actually evolved is a problem that still demands solution.

Table III.

Temperature of Extraction.	Volume in c.c. Total.	CO_2.	H_2.	CO.	CH_4.	N_2.	Percentage Composition. CO_2.	H_2.	CO.	CH_4.	N_2.
Sound Steel—Weight taken, 69.3 Grammes.											
Deg. C.											
519	6·53	0·07	6·37	0·07	0·02	0·00	1·07	97·54	1·07	0·30	0·00
600	10·67	0·19	8·44	2·00	0·07	0·00	1·78	79·10	18·74	0·65	0·00
672	12·87	0·35	8·07	4·40	0·07	0·00	2·71	62·70	34·18	0·54	0·00
688	22·91	0·75	6·96	15·02	0·12	0·03	3·27	30·38	65·56	0·52	0·13
719	12·61	0·07	4·74	7·72	0·06	0·01	0·55	37·58	61·22	0·47	0·08
765	6·71	0·02	3·35	3·26	0·05	0·02	0·29	49·92	48·58	0·74	0·29
802	4·29	0·00	2·24	1·97	0·08	0·00	0·00	52·21	45·92	1·86	0·00
862	4·59	0·05	2·24	2·22	0·08	0·00	1·08	48·80	48·36	1·74	0·00
936	5·04	0·03	2·53	2·42	0·07	0·00	0·59	50·19	48·01	1·38	0·00
979	5·64	0·01	2·83	2·75	0·04	0·01	0·17	50·17	48·75	0·70	0·17
Totals	91·86	1·54	47·77	41·83	0·66	0·07					
Steel with Blow-Holes—Weight taken, 63.2 Grammes.											
530	3·28	0·09	3·04	0·06	0·05	0·04	2·74	92·68	1·82	1·52	1·22
603	2·96	0·06	2·70	0·08	0·06	0·06	2·02	91·21	2·70	2·02	2·02
681	4·36	0·06	2·16	2·01	0·15	0·03	1·37	48·39	46·10	3·45	0·69
696	5·45	0·02	1·49	3·85	0·05	0·04	0·36	27·34	70·64	0·91	0·73
720	5·04	0·03	1·84	3·11	0·06	0·00	0·59	36·50	61·70	1·19	0·00
762	3·80	0·02	1·87	1·81	0·09	0·01	0·52	49·21	47·63	2·37	0·26
825	3·98	0·02	2·01	1·87	0·07	0·01	0·50	50·50	46·98	1·75	0·25
893	4·24	0·03	2·18	1·93	0·10	0·00	0·71	51·41	45·51	2·35	0·00
944	4·48	0·02	2·32	2·08	0·05	0·01	0·45	51·78	46·42	1·11	0·22
1,046	4·50	0·02	3·38	1·05	0·05	0·00	0·44	75·11	23·33	1·11	0·00
Totals	42·09	0·37	22·09	17·85	0·73	0·20					
Soft Steel Ingot—Weight taken 66.6 Grammes.											
411	2·79	0·04	2·68	—	—	0·07	1·43	96·05	—	—	2·51
525	2·37	0·01	2·33	0·01	—	0·02	0·42	98·31	0·42		0·84
609	6·05	0·01	5·90	0·13	0·01	0·00	0·16	97·52	2·15	0·16	0·00
667	4·92	0·08	4·58	0·27	0·01	0·00	1·62	93·09	5·48	0·19	0·00
720	7·26	0·31	3·64	3·29	0·02	0·00	4·27	50·13	45·31	0·27	0·00
786	17·19	0·24	5·24	11·63	0·07	0·00	1·40	30·48	67·65	0·40	0·00
836	13·20	0·10	4·19	8·67	0·13	0·11	0·76	31·74	65·68	0·98	0·83
885	7·03	0·01	3·33	3·54	0·13	0·02	0·14	47·37	50·35	1·84	0·28
965	8·03	0·01	3·99	3·89	0·13	0·01	0·12	49·68	48·44	1·61	0·12
Totals	68·84	0·81	35·88	31·42	0·50	0·23					

Table IV.—Bar—Weight taken, 67·7 Grammes.

Temperature of Extraction.	Volume in c.c. Total.	CO_2.	H_2.	CO.	CH_4.	N_2.	Percentage Composition. CO_2.	H_2.	CO.	CH_4.	N_2.
Deg. C.											
435	1·61	0·06	1·46	0·02		0·07	3·72	90·68	1·24		4·34
535	2·21	0·02	2·14	—		0·05	0·91	96·83	—		2·26
610	1·85	0·00	1·71	0·09		0·05	0·00	92·43	4·86		2·70
679	2·35	0·02	1·80	0·42	0·02	0·09	0·85	76·59	17·87	0·85	3·83
722	2·75	0·03	1·43	1·25	0·00	0·04	1·09	52·00	45·45	0·00	1·45
788	9·14	0·11	2·48	6·48	0·00	0·07	1·20	27·13	70·89	0·00	0·76
823	7·13	0·07	2·43	4·55	0·01	0·07	0·98	34·08	63·81	0·14	0·98
872	3·96	0·02	1·81	2·09	0·01	0·03	0·50	45·70	52·78	0·25	0·76
927	5·25	0·00	2·48	2·60	0·00	0·17	0·00	47·23	49·52	0·00	3·23
Totals	36·25	0·33	17·74	17·39	0·04	0·64					

* A contribution to a general discussion on "The Occlusion of Gases by Metals," at the Faraday Society, on Tuesday, November 12.

† Thesis for Master's Degree in Science, Massachusetts Institute of Technology.

Trade Correspondent for German East Africa.—The Administrator of German East Africa has notified the appointment of Mr. C. H. Chambers, Comptroller of Customs at Dar-es-Salaam to the position of Trade Correspondent of the Department of Overseas Trade (Development and Intelligence) for the territory of German East Africa.